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ORIGINAL ARTICLES.

I.—On a Preglacial Shoreline in the Western Isles of Scotland.

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(PLATE VI.)

THE preglacial[1] platform of marine erosion discussed in the following pages was first discovered in the Island of Colonsay in the course of the geological survey of that island carried out in the summer of 1907, and the information then acquired is communicated with the permission of the Director of the Survey. The subsequent tracing of the shoreline in the adjoining islands was effected with the aid of a Government grant for scientific research in the gift of the Royal Society of London. For clearness and convenience of reference the subject will be treated under the following heads:—

I. Introductory remarks indicating the aims of the investigation.
II. Colonsay and Oronsay—description of the preglacial platform.
III. Islay.
IV. Mull and Iona.
V. The Treshnish Islands.
VI. Conclusion, setting forth the present state of the subject.

I. Introduction.

In the isostatic problems connected with the Ice Age the determination of the preglacial sea-level is of primary importance. It is a datum to which subsequent oscillations of the shoreline may be referred, and as such affords a criterion for the discrimination of temporary and permanent deformations of the crust. A permanent glacial or postglacial deformation must show itself as a difference in level between the preglacial and present shorelines. On the other hand, a temporary oscillation, if complete, leaves no record of this kind, although it may be readily demonstrable in other ways. Now in the British Isles there is abundant evidence of both glacial and postglacial oscillations, and it is obviously important to determine to what extent the displacements effected have been temporary or permanent. The tracing of the preglacial shoreline has therefore in this respect a very special interest, and if successfully carried out might ultimately lead to the establishment or rejection of Jamieson's isostatic theory of the quaternary oscillations of sea-level.[2]

[1] Interglacialists will excuse the use of this term in the sense of prior to the only apparent general glaciation of the district in question.

[2] T. F. Jamieson, "On the History of the Last Geological Changes in Scotland": Quart. Journ. Geol. Soc., vol. xxi, p. 178, 1865.

Now the preglacial shoreline of the southern half of the British Isles has for some time past been fairly well known. Indeed, in the districts outside the glaciated area it has been the subject of papers from the very earliest days of geology, but its preglacial age was not at first recognized. It was not until Mr. Lamplugh [1] in 1888 described the buried cliff and beach beneath the drifts of Flamborough Head in Yorkshire that the first clue in this direction was obtained. From Yorkshire to the south coast of England, however, is a long cry, and the correlation was not readily made. In 1900, however, Mr. Tiddeman [2] showed that this shoreline of the south coast, which had been found also along the shores of the Bristol Channel, could be traced in South Wales beneath the boulder-clay, and he thus clearly established its preglacial age. Mr. Lamplugh [3] next proved its existence in the Isle of Man, and subsequently its presence was established along the whole south coast of Ireland and up the east coast as far as Dublin.[4] More recently it has been detected in Clare by the present author,[5] and in Kilary Harbour, county Mayo, by Messrs. Maufe & Carruthers.[5] Mr. Fearnsides [6] has also quite recently proved it to occur in Carnarvonshire in North Wales.

Thus it will be seen that in those portions of the British Isles lying south of a line through Yorkshire, the Isle of Man, and Mayo we are already well acquainted with the level of the preglacial sea, and it is remarkable that this level is almost coincident with the present sea-level. Throughout the greater part of this district it stands uniformly some 10 or 12 feet above the present high-water mark, and maintains a remarkable parallelism with the present shore. This parallelism proves almost beyond a doubt that no marked permanent deformation by folding or faulting has taken place over this wide area since preglacial times. It would perhaps be safer to qualify this statement somewhat and to say instead that if any such deformation has occurred within the area it is entirely exceptional and local. We have, however, no definite indication of any displacement of the kind, and, even if such did occur, it cannot affect the conclusion that has just been drawn regarding the general stability of the region.

Now throughout this apparently stable district there occur submerged forests and peat beds often at a considerable depth below sea-level. The oscillation which allowed of their formation we must therefore regard as temporary, at least in the sense that the sea has

[1] G. W. Lamplugh, "Report on the Buried Cliff at Sewerby": Proc. Yorkshire Geol. and Polytec. Soc., vol. ix, pp. 382–92, 1889, and Rep. Brit. Assoc. for 1888. See also "Drifts of Flamborough Head": Quart. Journ. Geol. Soc., vol. xlvii, p. 394, and Proc. Yorks. Geol. and Polytec. Soc., vol. xv, pp. 91–5, 1903.

[2] R. H. Tiddeman, "On the Age of the Raised Beach of Southern Britain as seen in Gower": Rep. Brit. Assoc., 1900, p. 760.

[3] G. W. Lamplugh, "Geology of the Isle of Man," p. 14: Mem. Geol. Surv. U.K., 1903.

[4] W. B. Wright & H. B. Muff (now Maufe), "The Pre-glacial Raised Beach of the South Coast of Ireland": Sci. Proc. Roy. Dublin Soc., vol. x (N.S.), pt. ii, p. 250, 1904.

[5] Descriptions not yet published.

[6] W. G. Fearnsides, "The Tremadoc Slates and Associated Rocks of South-East Carnarvonshire": Quart. Journ. Geol. Soc., vol. lxvi, p. 182, 1910.

since assumed a level differing but little from one which it occupied long before the oscillation took place. The further question as to whether the postglacial raised beaches[1] of the British Isles are in the same sense the result of temporary oscillations is not as readily solved. It would be quite unsafe to generalize from the one case to the other; for the raised beaches and submerged forests have this essential difference, that the latter are widely distributed phenomena, whereas the former are distinctly grouped round a centre in the Scottish Highlands. This centralization of the raised beaches indicates that the oscillations they record have a different cause from that of the submerged forests. This being the case, the tracing of the preglacial shoreline into the area occupied by the postglacial beaches assumes a double interest.

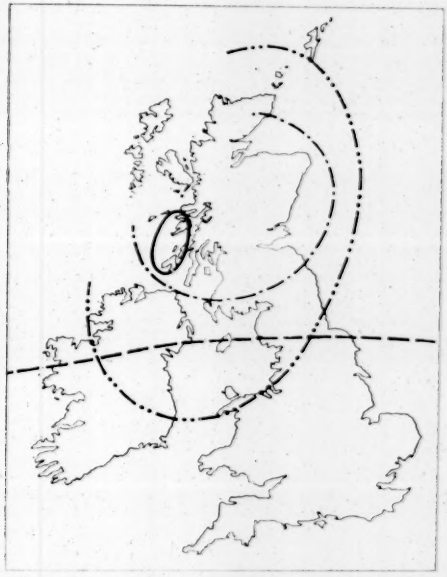


FIG. 1. Diagram to show the distribution of the various beaches as at present known.

———— Preglacial beach of the Western Isles of Scotland.
— — — Northern limit of preglacial beach of Southern Britain.
— · — · — 100-foot late glacial beach of Scotland.
— ·· — ·· — Post glacial, Neolithic beach, so-called 25-foot raised beach.

Up to the present, however, very little has been effected in this direction. Some significance may attach to the fact that the preglacial

[1] For the benefit of readers who do not happen to be acquainted with the subject it may be mentioned here that two distinct raised beaches are known in Scotland, namely, the 100-foot late-glacial beach (with probably associated shorelines at lower levels) and the 25-foot postglacial or Neolithic beach. Their periods of formation were separated by one of elevation in which submerged forests were found.

shoreline is slightly lower in Yorkshire and the Isle of Man than further south. In Yorkshire the inner angle of the preglacial platform lies a few feet above high-water mark, in the Isle of Man approximately at high-water mark. The former of these localities lies a short distance outside the area of distribution of the so-called '25-foot' postglacial raised beach, the latter fairly well within it. This may possibly be an indication that towards and within the area of the postglacial raised beaches the preglacial raised beach has suffered a depression from which it has not yet recovered.[1] Its apparent absence over the greater part of Scotland might therefore be due to its being entirely below sea-level and thus unobservable.

Recently, however, some discoveries in the Western Isles of Scotland have shown that the problem is a much more complex one than had formerly been supposed. Throughout an area embracing Islay, Colonsay, Mull, and the Treshnish Islands there is a pronounced and locally well-preserved shoreline of preglacial age at a height varying from 90 to 135 feet above sea-level. This rather startling disclosure has of course been the basis of many speculations, but it is doubtful if these have as yet any permanent value. The existence of the shoreline is, however, beyond question, as is also its preglacial age. We shall devote the succeeding paragraphs to an account of its development in the different islands, and conclude with some general remarks.

II. Colonsay and Oronsay.

The old plain of marine erosion can be traced throughout the greater part of Colonsay and Oronsay, and is one of the most remarkable physiographical features of the islands. It has suffered somewhat from glacial and perhaps also subaerial denudation, and large areas of it have been removed at various stages by the sea. Nevertheless here and there wide stretches are preserved, and it is possible in many places to trace its inner margin, which is frequently marked by a line of lofty cliffs.

A pronounced feature of the platform is the manner in which it is locally dissected by slacks and hollows. It is to be noted, however, that many of these may have pre-existed the cutting of the platform, and therefore do not necessarily represent the extent of subaerial and glacial erosion since its formation. If there has been any marked subaerial modification of the original form of the plain, which may well be doubted, it has clearly been effected in preglacial times, for the postglacial denudation has been very slight. One finds few or no hollows of obviously postglacial date, and the amount of atmospheric weathering since the Ice Age has also been quite trifling. Everywhere one finds the surface of the plain ice moulded, and in many places it is striated and covered by boulder-clay; the old line of cliff also frequently shows marks of the passage of the ice, and one cannot but be struck by the slight modification which these much exposed glaciated surfaces have undergone.

[1] As opposed to this, however, it should be noted that the scanty remnants of the preglacial platform found at Bray Head in Wicklow, which lies just within the area of distribution of the 25-foot beach, do not show any marked depression.

This remarkable rock-shelf and its accompanying cliffs are best preserved in Uragaig to the west of Kiloran Bay (see Fig. 2). The platform is here nearly half a mile wide, and probably once extended much farther seaward. Its inner angle beneath the magnificent cliffs of Tornach Mor is about 135 feet above high-water mark of ordinary spring tides. It can be traced from here round the west coast for about a mile and a half to Port Ban, forming along this coast the grassy platforms between the upper and lower cliffs known as Aonan Ceann a' Gharràidh, Aonan nam Bo, Aonan Mhic Mhuirtean, and Aonan nam Muc.[1] South of the last-named locality no sure trace of it can be found along the cliffs as far as the south side of Binnein Riabhach. Here a great strip of the platform can be seen stretching away inland towards Upper Kilchattan, although it is much denuded and its inner margin is ill defined. South of Port Mor, however, the old coastline is marked by a fine cliff forming the western faces of Beinn nan Caorach and Sliabh Riabhach. The pass to the south of the last-mentioned hill was a strait at the time of the formation of the old shoreline, and the platform can be traced right through it to Scalasaig along the north side of the road.

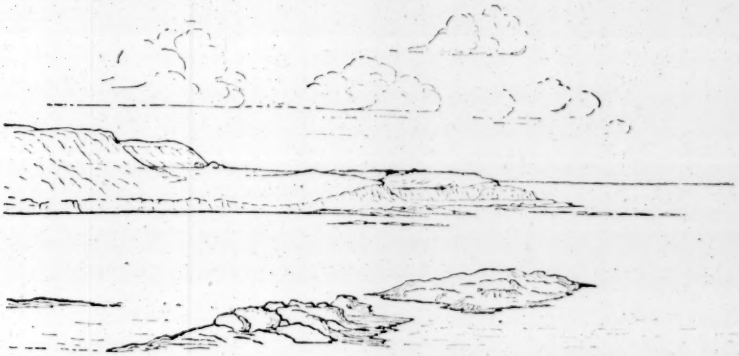


Fig. 2. Uragaig from the north side of Kiloran Bay, showing the cliff and rock-platform of the 135-foot preglacial raised beach.[2]

The higher parts of the southern half of Colonsay, with Beinn Oronsay, formed at this period outstanding islands with a series of

[1] Aonan means a grassy pasture open to the sea, and surrounded by rocky cliffs. It does not strictly imply "a step between the higher and lower cliffs", as stated by Mr. Symington Grieve, although it often is so. A small aonan, the Aonan nam Clach Mòra, north of the Cailleach Uragaig, is a grassy flat of beach gravel surrounded by cliffs and lying only a little above high-water mark. A former proprietor of the inn at Scalasaig, Mr. Donald M'Neill, being worried by his guests as to the meaning of Aonan nam Muc, translated it for their benefit as The Pig's Paradise, and by this name it has been commonly known since. To Mr. Grieve belongs the credit of having first recognized that some of the higher aonans along the west coast owe their origin to marine erosion; he does not, however, appear to have noticed that they are of preglacial age. See Proc. Soc. Ant. Scot., vol. v, p. 351, 1882-3.

[2] Figs. 2 and 3 are reproduced, by permission of the Controller of H.M. Stationery Office, from the Geological Survey Memoir on Sheet 35, Scotland.

narrow straits between (see Fig. 4). The platform of erosion among these islands is in a few places still well preserved, as on the plateau known as Lòn Mòr to the south-west of Loch Staosnaig. A distinct shelf can also be traced round Beinn Eibhinn, and it is again particularly well marked on the south side of Beinn Oronsay.

Some outlying hills in the north of Colonsay were also isolated, while the big inland cliffs south of Balnahard marked, at this stage, the coast of the main island.

On the east side of the islands the effect of full exposure to the impact of the ice is noticeable in the planing down of the platform and the rounding off of the old cliff feature. This is, of course, especially marked in the softer, more pelitic beds, but where the rock-shelf is cut in the harder grits, as in the case of some of the headlands north of Scalasaig, both cliff and platform are sometimes well preserved (see Fig. 3).

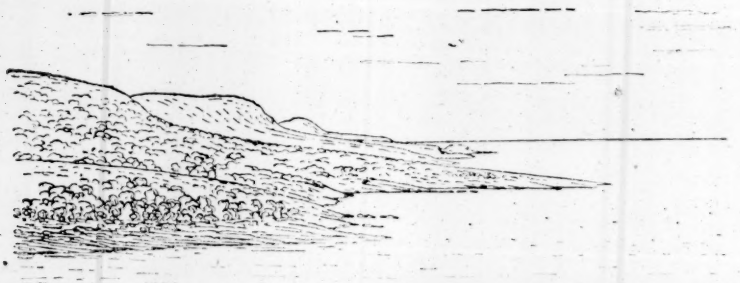


FIG. 3. The shores of Colonsay looking north from Port Olmsa, showing the preglacial cliff and rock-platform and the ice-planed slopes of the east coast.[1]

In addition to this well-marked high-level platform there exists another, first pointed out by Mr. Bailey, which lies a little above sea-level, and may perhaps also be taken as indicating a preglacial plain of marine denudation. This lower platform includes a considerable portion of the low-lying ground in Oronsay, and also the ice-worn skerries, many of them covered at high tide, which render the western coast so dangerous to navigation. There is also a suggestion that the fine sea-cliffs along the coast from Kilchattan north are not entirely postglacial. The evidence, however, for this lower preglacial plain is very poor, and little reliance can be placed on it. It rarely or never has a well-defined inner margin or a cliff that can be traced any distance. One point, however, which lends it some support should be mentioned here. A plain at a similar level has been observed in the Torridonian rocks on the east coast of Iona along the shores of the sound separating Iona from the mainland of Mull. This shelf is overlain by the gravels of the 25-foot beach, but it is clear that it does not belong to this beach, since there is no cliff at the back of it at all equivalent in magnitude to the extent of the plain, but instead a rounded ice-worn slope.

[1] See note 2, p. 101.

III. Islay.

Along the north-west coast of Islay between Loch Gruinart and the Rudh'a' Mhàil the preglacial platform of marine erosion has a very magnificent development. The relations here, however, are obscured, and have escaped the notice of former geologists owing to the fact that the rock-platform of the preglacial shore is everywhere overlain by the copious gravels of the postglacial 100-foot beach. The platform came thus to be regarded as the work of the 100-foot postglacial sea. Apart, however, from the fact that nowhere else has this sea been able to erode anything beyond the most trifling notch in rocks of the hardness of the Islay quartzite, there is ample evidence that the rock-platform is of much earlier date. The cliff at the back of the 100-foot beach is in many places composed of boulder-clay, and the rock-platform on which the gravels rest passes beneath this boulder-clay; while from behind the boulder-clay there rises again a steep hill face of rock, evidently the old cliff corresponding to the rock-platform. The boulder-clay thus lies packed into the angle between the cliff and the platform. Moreover, if we follow the present sea-cliffs, which show in section the outer portion of the platform capped by the 100-foot gravels, we find here and there between the gravel and the platform lenticles of boulder-clay which lie on slightly lower portions of the platform, and which have been planed off above by the action of the 100-foot sea.

Both these phenomena are well seen in the neighbourhood of the Mala Bholsa. Immediately north of the small stream which enters the sea south of this hill the gravel of the 100-foot beach rests on boulder-clay, which lies in a slight hollow of the preglacial platform. The matrix of the boulder-clay is here a quartzite meal of the nature of pasty sand, but the structure of the deposit leaves no doubt that it is boulder-clay. Also about 200 yards north-east of this the cliffs of the Aonan na Mala immediately below the Mala Bholsa show the following section:—

Angular gravel	4 feet	100-foot beach deposits.
Stratified sand	4 ,,	
Boulder-clay	7 ,,	
Rock-platform.		

A great mass of drift is banked up on the west side of the Mala Bholsa, and in the cliff of the Aonan na Mala the preglacial platform is seen passing horizontally beneath it. The great geo or sea-cut gully, which a little to the north runs up towards the Mala Bholsa, shows in section this remarkably even platform beneath the drift to within 30 yards of its junction with the cliff-slopes of the hill. Measurement with an Abney level from high-water mark of spring tides gave 105 feet as the level of the platform at the innermost visible point, i.e. about 30 yards from the rock-cliff. A hollow in it contains a small patch of quartzite rubble beneath the boulder-clay.

From the Mala Bholsa magnificent views can be obtained both to the south-west and east of this striking plain of marine erosion with its overlying but utterly unconnected sheet of postglacial beach-gravel.

On the west coast of the Oa of Islay some remnants of the preglacial platform are also preserved, although along the greater part of the

coast it has been entirely removed by the recent encroachments of the sea. These remnants occur between Allt Tràigh Leacail and Lower Glen Astle, and also on Rudha Ruadh west of Maol an Fhithich. They are loaded with drift, so that no doubt can be felt as regards their age. The cliff behind is generally somewhat rounded off at the top. Measurement with an Abney level showed that the inner angle stands about 95 feet or so above high-water mark of spring tides.

IV. Mull and Iona.

In the districts already described it has been possible to demonstrate satisfactorily in every case the preglacial age of the rock-platform. In Mull, however, where it has its most persistent and remarkable development over long stretches of coast, this has been found extremely difficult. No boulder-clay has been found overlying the platform and no striæ have been observed on its surface. In a few cases only has it been possible to detect distinct ice-moulding on rocks which are undoubtedly portions of the platform, and these cases had to be sought for with some diligence. Even apart from the finding of these ice-moulded surfaces, however, there can be little doubt regarding the identity of the Mull platform. Its striking development, great width, and the imposing character of the cliff by which it is backed, make it impossible to refer it to the action of the postglacial sea, the cutting effect of which in other parts of Scotland has been comparatively trifling in amount.

The presence of the preglacial beach can be proved here and there along most of the west coast of Mull, but it forms a really striking feature of the scenery from Ulva and Gometra north to the Caliach Point in Mornish. In Gometra the platform is much dissected by hollows and geos, but the remnants of it preserve on the whole a fairly uniform level, and the old cliff behind is very well preserved. The inner angle is distinctly marked for a distance of about a mile and a half around the west and south sides of the island. At its northernmost extremity it is finely developed at a height of 105 to 118 feet above high-water mark of spring tides. On the south coast on both sides of Gometra House measurement gave 110 feet as the height of the inner angle. Traced east along this coast, however, it appears to decline somewhat, measurements giving successively the figures 105, 100, and 95 feet at different points within half a mile east of Gometra House. An outlying portion of the platform along the west coast appears to have a distinctly ice-moulded surface. On the north and south shores of Ulva there are some irregular shelves, which might be interpreted as portions of the preglacial marine platform, but, as little reliance can be placed on them, they will not be described here.

The preglacial platform fringes with almost perfect continuity the whole west coast of Mull from Port Burg to Treshnish Point, being everywhere backed by very fine cliffs about 200 feet high. Being, like the modern shore, controlled to a large extent by the relative strength of the gently inclined basalt flows, it varies a good deal in height. Where softer strata overlie a powerful lava bed it may begin at a certain spot quite low (100 feet or so above high-water

mark) and rise along the dip slope of the lava bed, until it is perhaps 20 feet higher than when it started on this bed. When, however, it reaches an altitude of 120 or 125 feet it invariably breaks through the strong bed and begins again at a lower level. At Rudh' à Chaoil, where the lavas lie approximately horizontal, a magnificent level platform with cliffs nearly 300 feet high is developed at a height of 120 to 125 feet above high-water mark of spring tides. The platform is here and in other places along this coast nearly a quarter of a mile wide, and it is impossible to confound it with the ledges produced by the irregular weathering of the basalts. The persistence of its general level for the distance of 5 miles, throughout which it is here continuously developed, places its marine origin beyond doubt. Opposite a hollow in the preglacial cliff east of Rudh' à Chaoil the surface of the platform has a distinctly ice-moulded appearance.

The southern shores of Calgary Bay show only some very doubtful remnants of the preglacial beach, but on its northern side the platform resumes the magnificent development exhibited along the coast to the south, and this it maintains round the coast of Mornish to the north as far as the Caliach Point. It shows the same tendency to conform in level to the upper surface of strong beds, but, as before, abandons these beds when they depart too much from its normal level. In one or two places its surface has an appearance of ice-moulding. A measurement of height made about one mile south of the Caliach Point gave 115 feet as approximately the normal level in this vicinity, but the inner angle rises in places to 120 feet and sinks in others to 105 feet. Another estimate at the head of Calgary Bay gave 110 feet as about the normal, while portions of the platform are as low as 95 feet and others rise to 115 feet.

South of Loch na Keal the Mesozoic rocks of Gribun afford no certain traces of the preglacial beach, but at the foot of the magnificent escarpment known as The Wilderness, to the west of Ardmeanach, well-marked remnants can be seen. It is probable that along this coast considerably more of the platform is preserved than appears to view, for the whole is much obscured by scree and landslips descending from the immense cliffs above. As we pass south along the coast from the farm of Balmeanach certain obscure traces are seen at Coireachan Gorma, but the first undoubted remnant occurs at Stac Glas Bun an Uisge just to the north of the river. Half a mile further south, at Rudha nan Goirteanan, it is, however, much finer, being cut in the schistose grits of the Moine Series. The platform is here much obscured by material from the cliffs above, but the section afforded by a geo enables it to be traced beneath the scree almost into its inner angle. Measurements showed the highest portion seen to lie at a height of 98 feet. The inner angle is probably a few feet higher. The cliff is composed of the same schists as the platform, and appears where seen to be somewhat rounded and moulded. The great cliff above from which the scree descends is not the cliff of the raised beach but the escarpment of the Tertiary lavas. The surface of the preglacial platform is ice-moulded. It probably extends continuously from here to Uamh nan Calman. At Rudha na h'Uamha there is a volcanic neck with associated columnar basalts.

A well-marked platform cut in these latter can be seen emerging from beneath the scree. It probably extends south of the point for some distance. Levelling showed its height to be about 110 feet, where it can be seen passing beneath the scree, but its inner angle is probably a little higher, say 115 feet.

In Iona remnants of the preglacial beach are poorly preserved. It possibly never attained any regularity or perfection of development here owing to the nature of the country rock. There seem, however, to be traces of it on the south-east face of Drum Dhùgaill and the hill to the north, and also west of Dùn Cùl Bhuirg, where many of the crags are reduced to a level of 115 to 130 feet, but very irregularly. On Erraid and north of Fidden, on the adjoining coast of the Ross of Mull, there are considerable areas at about the same level, which may be portions of the old platform much modified by glaciation.

V. The Treshnish Isles.

The Treshnish Isles are a small group lying to the west of Mull outside Gometra and Staffa. Only two of the islands, the Bac Mor and Lunga, are of sufficient height to show the preglacial shoreline, but on both of these it is remarkably developed. The Bac Mor, commonly known as the Dutchman's Cap, is a striking object. Visitors from the neighbourhood of Oban who have seen the beautiful terraces of the 25-foot beach surrounding the islands of that district cannot fail to recognize here a similar phenomenon on a much grander scale. From the broad platform of the preglacial beach which forms the rim of the hat, the central eminence rises steeply to a height of 284 feet above O.D. The platform, which forms more than two-thirds of the area of the island, lies almost entirely below the 100-foot contour. The slope of the platform, which is higher at the north end, is more or less controlled by the rock-structure, the slight dip of the lavas (as apparent when viewed from the south-east) being towards the south or south-west in the Bac Mor and towards the north in the Bac Beag. The control is, however, not nearly so marked as might at first sight be imagined, and there is no bed sufficiently strong to lead to the production of the shelf through atmospheric weathering or glacial erosion alone. The shelf, indeed, shifts from one bed to another, and in this manner varies considerably in level.

Owing to the absence of any modern beach deposits and of the zone of *Fucus canaliculatus*, which indicates the high-water mark on most rocky coasts, accurate determinations of level were rendered rather difficult. As a datum it was necessary to take the upper limit of Balanus, a much less reliable index of high water than the seaweed zones. Estimating from this, however, the inner edge of the platform round the south side of the central hill was found to be from 75 or 80 feet to 90 or possibly 95 feet above high-water mark of spring tides. The general level of the more outlying portions of the platform at this south end was 70 to 75 feet, rising to near 80 feet on the Bac Beag.

At the north end of the central hill, with the same difficulty of determining high-water mark, the inner angle was found to be at

a height of from 90 to 95 feet. At the extreme north end of the island the platform is on the whole a few feet higher, say 97 feet above high-water mark. At the west side of the central hill there appears to be a higher fragment of platform at 110 feet, but this is rather doubtful.

The platform is everywhere remarkably ice-moulded. No striæ were observed, but from the aspect of the *roches moutonnées* it is clear that the ice came from the N.E. or E.N.E., an observation agreeing with the trend of the striæ in Ulva.

Lunga, the largest of the Treshnish Isles, has a still more extensive platform, which occurs all round the island except for local interruptions in one or two places. The lavas lie nearly horizontal with a very gentle dip to the north. The platform at the north end is controlled by the occurrence of a very massive lava bed some 80 or 100 feet thick. The inner angle at the ruined houses is just 100 feet above high-water mark of spring tides. As the massive bed is followed south along the east side of the island it rises steadily and carries up the platform with it to a height of 110 feet or more. Soon, however, the platform abandons the massive bed and starts again to the south of Cruachan at a lower horizon in the lavas. Here, as in the case of the Bac Mor, it is at a very low level, the inner angle being only 80 or 85 feet above high-water mark of spring tides, and the general level of the platform, which extends for three-quarters of a mile to the southern extremity of the island, only 75 or 80 feet. At the extreme south end it appears to rise again to 85 feet. Along the west side only irregular remnants are preserved.

Along the north, east, and south of the island the platform is even more remarkably ice-moulded than on the Bac Mor, so that there is absolutely no doubt as to its preglacial age. The ice-motion was, as before, from the N.E. or E.N.E., but no striæ were found.

VI. Conclusion.

The continuity of the old cliff and platform along stretches of coast many miles in extent, and the manner in which the latter maintains a uniform level independently of, and often in spite of, the rock-structure, are sufficient proof that we are dealing with an old shoreline. The repeated ice-moulding of the surface, and above all the superposition in some localities of large masses of boulder-clay, show that the feature was in existence before the Great Ice Age. Its development as a rock-platform is quite comparable with that of the preglacial beach of Southern Britain, but a correlation between the two would at present be very unsafe. The main obstacle is of course the want of preservation of deposits in connexion with the platform of the Western Isles. Even in the absence of these it might be possible to correlate if we could be sure that these old shorelines were the only ones of immediately preglacial age in their respective districts. At present, however, we cannot be sure that other platforms of marine erosion do not exist below sea-level. Moreover, in the south of Colonsay and in Oronsay there are vague indications, first pointed out by Mr. Bailey, of a possible plain of marine erosion a little above the present sea-level. The

evidence for this second preglacial platform, to which reference has been made above (Section II), cannot, however, at present be regarded as at all satisfactory, and unless its existence is confirmed by evidence in other districts it need not be taken into account theoretically.

In Southern Britain the deposits of the preglacial raised beach are overlain by 'head' or 'rubble-drift', and a conspicuous feature of the preglacial shoreline is the rounding off of the old sea-cliff owing to atmospheric degradation at the time of formation of this head. It is worthy of note that where the preglacial cliff of the Western Isles is best preserved, as in Mull and parts of Colonsay, no such

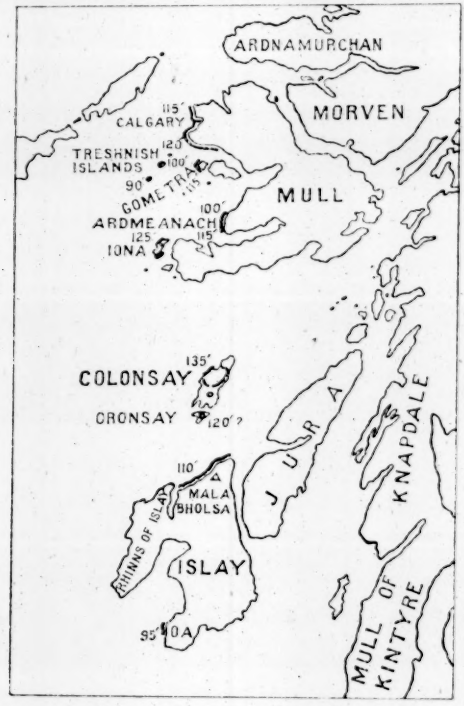


FIG. 4. Sketch-map on the scale 25 miles to the inch, showing the known localities and heights of the preglacial raised beach of the Western Isles of Scotland. The preglacial beach is shown by a black line, and the figures give its observed heights in the different localities.

rounding is observable. Some allowance must no doubt be made for the nature of the rocks of which the cliff is formed, but, taking everything into account, there is a distinct suggestion that the Scottish cliff was never exposed to the same process of degradation as that of the south. It may possibly have been below sea-level, but it is more likely that it was already buried in ice long before the

setting in of the severe climatic conditions which caused the formation of the head.

A review of the various measurements quoted above and a consideration of the maximum heights of the platform in the different islands (see Fig. 4) would seem to indicate some deformation of the shoreline. Owing, however, to the possibility of cumulative errors of observation, to the probability that the inner angle did not always bear the same relation to high-water mark, and to the subsequent extensive modification by glaciation, I do not at present wish to lay much stress on this point.

Having up to the present avoided all considerations of a speculative nature, I may perhaps be permitted in conclusion to suggest a working hypothesis. It is well known that the late-glacial 100-foot beach is confined to certain parts of Scotland, being absent in England, Ireland, and the extreme north of Scotland (Caithness) (see Fig. 1). Throughout its area of distribution it maintains, moreover, a fairly uniform level of 100 feet above the sea, and where it disappears it does so abruptly, not dipping gradually below sea-level like the 25-foot beach. Now the (0 to 12-foot) preglacial beach of Southern Britain has not been traced within the area of the 100-foot beach. Well within this area we find, however, the (100 to 135-foot) preglacial beach of the Western Isles. Now, making the admittedly dangerous correlation between the two preglacial beaches, the approximate coincidence of figures suggests that the movement (possibly block-faulting) which brought the 100-foot late glacial beach into its present position was also responsible for the elevation of the preglacial beach in the Western Isles of Scotland.

II.—Notes on British Dinosaurs.[1] Part IV: *Stegosaurus priscus*, sp. nov.

By Baron Francis Nopcsa.

(WITH NINE ILLUSTRATIONS IN THE TEXT.)

SINCE the *Omosaurus* of the Kimeridge Clay may still be regarded as the only well-known European representative of the Stegosauridæ, it seemed advisable, after discussing in previous papers the Ornithopodous *Hypsilophodon* and the Acanthopholidid *Polacanthus*, to examine a representative of this type. I am therefore greatly indebted to Dr. A. S. Woodward for permitting me to do so at the Natural History Museum, and also for putting at my disposal a magnificent hitherto undescribed Stegosaurian discovered by Mr. Alfred Leeds, F.G.S., in the Oxford Clay of Fletton, near Peterborough.

On account of the small elevation of the neural arch of the dorsal vertebræ I propose to name this new Stegosaurian species *Stegosaurus priscus*.

The type-specimen of *St. priscus* in the Natural History Museum bears the register number R. 3167, and is represented by numerous

[1] Part I, *Hypsilophodon*, with a page illustration, appeared in the Geol. Mag., 1905, pp. 203–8; Part II, *Polacanthus*, op. cit., pp. 241–50, with Plate XII and 8 text-figures; Part III, *Streptospondylus*, op. cit., pp. 289–93, Plate XV (all in Decade V, Vol. II, 1905).

bones; a second individual, of which the distal end of the pubis and some dermal plates have been described by von Huene as *Stegosaurus* sp.,[1] is in the Sedgwick Museum at Cambridge.

The type-specimen of *St. priscus* is represented by the following material: 2 anterior cervical vertebræ including the axis, 9 dorsal vertebræ or fragments of such, 15 caudal vertebræ, 1 cervical rib, fragments of chevron bones, 3 left and 1 right dorsal ribs, the right humerus and ulna, the left femur and parts of the corresponding tibia and fibula, carpal bone, astragalus, and calcaneum, fragments of both ilia, parts of both pubic and ischiac bones, parts of the dermal armour.

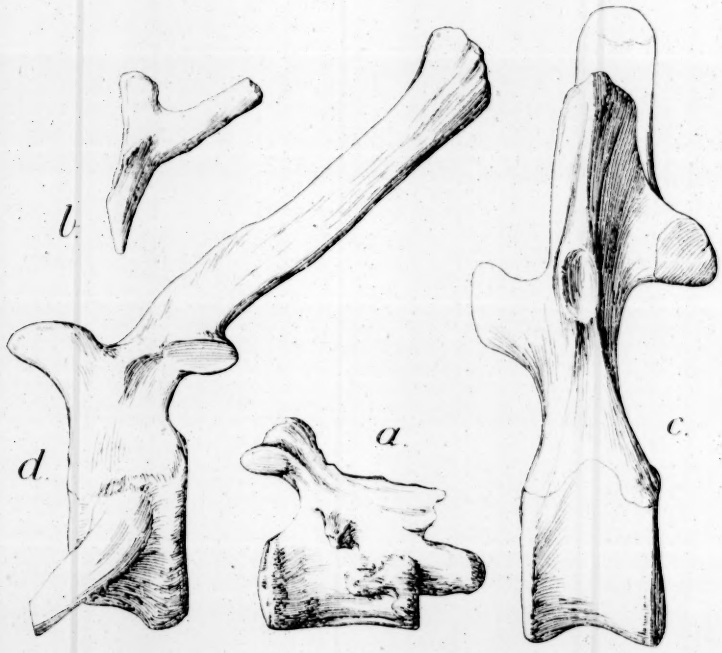


Fig. 1. *a*. Axis of *St. priscus* seen from the right (most of the neural spine wanting). *b*. Anterior cervical rib of same. *c*. Dorsal vertebra of the same. *d*. Middle caudal vertebra of the same.

Vertebræ.—The axis of the Fletton Dinosaur is of special interest, for hitherto no axis of a Stegosaurian has ever been described or figured. It is 12 cm. long; at the posterior end its body is 4·8 cm. wide and 4·5 cm. high. Unfortunately the neural arch is much mutilated, as shown in Fig. 1*a*.

The odontoid projects far forward; the centrum is strongly compressed laterally, but as shown by the irregular split-like section of the neural canal this is to some degree due to post-mortem deformation. This deformation has also caused the basal keel of the centrum to be more

[1] Centralblatt für Mineralogie, Geologie, und Palaeontologie, Stuttgart, 1902.

marked in the fossil than it may have been in the living animal. The anterior and inferior margins of the centrum show strong rugosities. On the posterior margin two hypapophysial knobs are present. The anterior articular surface of the centrum is plane, the posterior moderately concave; both surfaces show a straight superior and equally rounded lateral and inferior border, having thus the shape of a circular disc, of which a segment is missing.

The articular surfaces for the first cervical rib are situated on the anterior superior part of the centrum, and on the middle of the arch immediately above the neuro-central suture. The neural arch is much mutilated, and only one post-zygapophysis is preserved, which is situated comparatively high above the centrum. Its articular surface is not clearly defined, and is directed outward and downward.

With the exception of its being a few millimetres shorter, the second vertebra, of which only the centrum is preserved, has practically the same shape as the axis, the chief differences being the stronger development of the hypapophysial knobs and the evidently more elevated pleurapophysis, for no trace of it can be found in the part preserved. Compared with the cervicals of the new *O. Lennieri*, preserved at the Havre Museum, the description of which will shortly be published elsewhere, there is a great difference in the laterally compressed centra of *St. priscus* and also in the rectangular shape of the neural platform (Hulke), which is sandal-shaped in *O. Lennieri*, being strongly contracted in the middle. No great difference between the cervicals of our *Stegosaurus* and the American *Stegosaurus* is apparent.

It does not seem improbable that the left triradiate cervical rib, represented in Fig. 1*b*, belonged to this or to the following vertebra, for the distance of the capitulum and tuberculum would correspond to the proportions we should expect to find in these vertebræ if they were complete.

Besides two processes for the capitulum and tuberculum and the comparatively short and flattened body of the rib, this bone shows on the exterior part a well-marked excrescence, which is represented in most Dinosaurs only by a feeble ridge, but is well developed, though with altered direction, on the cervical rib figured by Marsh as a rib of *Apatosaurus*. In *Stegosaurus* this excrescence is pointed outward and forward, and it may perhaps be best compared with the dilatation of the cervical ribs in some Lacertilia. It may have served for the purpose of combining a limited amount of flexibility with strength in this region of the body. A quite similar, though more ridge-like excrescence is also met with on the thoracic ribs of *Stegosaurus*, and produces there, together with a similar posterior ridge, the oblique T-shaped cross-section that has been specially noticed in *Stegosaurus*, but seems, as far as I am aware, to be present also in other members of the Orthopodous order.[1] Its origin may therefore have to be explained otherwise than through the weight of the dermal armour.

The dorsal vertebræ of *St. priscus* (Fig. 1*c*) approximate in general

[1] I would suggest that the Dinosaurians represent a distinct super-order, which may be divided into two orders, Saurischia (Seeley) and Orthopoda.

to the type of *St. ungulatus* and *O. armatus*. Several differences, however, may be noted as distinguishing this species quite clearly from either of the others.

In *St. ungulatus* the point from which the diapophysis arises is much higher above the bottom of the neural canal than in our specimen; in *O. armatus* this point is very much lower. Corresponding with this difference the elevation of the prezygapophysis in our specimen is also intermediate between that in the two other animals; while *O. Lennieri* shows much the same stage of specialization as *O. armatus*. The direction of the diapophyses is also different in the different animals, for they are directed more outward than upward in *O. armatus*, more upward than outward in *St. ungulatus*, and equally outward

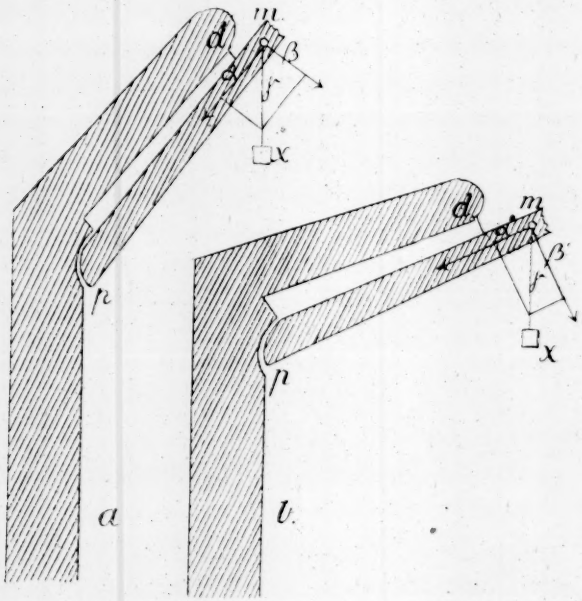


FIG. 2. Diagram illustrating the difference of strain on the diapophysis as correlated with the elevation of latter. *a*. Stegosaurian type. *b*. Omosaurian type. *p* = parapophysis; *d* = diapophysis; *x* = weight of dermal armour acting on the rib by *m*; γ = amount of vertical pressure; α (α') = pressure on parapophysis; β (β') = strain on diapophysis.

and upward in *St. priscus*, the angle that they form with the neural spine being in the latter just about 45 degrees. Comparing these data with *Scelidosaurus*, we remark that the elevation of the diapophyses steadily increases as these animals specialize. Since the bones of these animals are not pneumatic, and since a similar elevation is not present in the mammalia, though in these the development of lungs is much more important than in reptiles, I do not believe this elevation had anything to do with the development of the lungs as generally accepted, but I think it is rather due to the increasing

weight of the double row of dorsal plates. It is evident that a rib fixed to the parapophysis and diapophysis in the Stegosaurian way was much more fitted for supporting weight than one in which the two points of attachment were nearer to each other and more on a horizontal plane, with the rib directed nearly at right angles to the vertebral column.

To illustrate this the diagrams Fig. 2*a* and 2*b* were drawn according to the evidence afforded by *O. armatus* and *St. ungulatus*. By breaking up in these figures the vertical pressure of the dermal armour on the rib γ into its components α (α') and β (β'), it becomes clear that in *St. ungulatus* (Fig. 2*a*) the strain (β) on the diapophysis (d) is by m just about half as strong as in *O. armatus* (Fig. 2*b*, β') while the pressure α (α') on the parapophysis (p) is augmented, for $\alpha' = \frac{\alpha}{2}$ and β' is larger than β. In animals where the dermal armour becomes supported by the vertebral column and not only by the rib, as in crocodiles, tortoises, Ancylosauridæ, and some others, such an elevation of the diapophysis need not be developed.

Even the strong downward curve of the rib beyond its culminating point, reducing as it does the transverse diameter of the body-cavity, is probably more due to the pressure of the dermal armour than to anything else, for it is evident that with a rib curved strongly downward the dilatation of the body-cavity, as necessary for breathing, can be easily brought about by contraction of the musc. levator costarum without shifting the weight of the dermal armour, while this would be impossible if the distal ends of the long ribs were not directed downward but outward.

Since *Stegosaurus* was probably a cold-blooded animal, the increase of body-surface and greater loss of heat as resulting from the lateral compression of the body would, of course, in this animal not be of so great importance as in a warm-blooded animal, where there is a minimum of body-surface united with greatest capacity for the respiratory organs; thus a more rounded body-section is needed.

Two other quite marked features of the dorsal vertebræ of *St. priscus*, in which this animal makes a close approach to *St. ungulatus*, are the lateral compression of the neural canal and the absence of cavities on the sides of the centrum. The shape of the transverse and longitudinal sections of the plano-concave centra seem, however, otherwise to be the same in both Omosaurs and Stegosaurs.

A good view of a middle dorsal vertebra is given in Fig. 1*c*, which is based principally on one bone, but has both zygapophyses restored on evidence afforded by another specimen.

The sacral vertebræ are all wanting in *St. priscus*, but the proximal middle and distal caudals are each represented by numerous pieces.

The anterior caudals (Figs. 3*a*, *b*) are of the same type as in *Omosaurus*, the chief difference being only that the tubercle on the superior border of the dilatated costoid is somewhat less developed in the former than in the latter. On these strongly abbreviated vertebræ no chevron bones seem to have articulated. The proximal caudals of *St. priscus* are easily distinguished from *St. ungulatus* by the weaker development of the neural spine and the costoids.

The middle caudal vertebræ (Fig. 1*d*) of *St. priscus* have the neural spine more elevated than in *O. armatus*, but not cleft at the top as in *St. ungulatus*. The section of the rod-like neurapophysis is triangular at the base, but oval and somewhat laterally compressed at the summit. The post-zygapophyses are not much elevated above the neural canal, they are directed both straight downward and outward. The pre-zygapophyses are correspondingly directed upward and outward. The

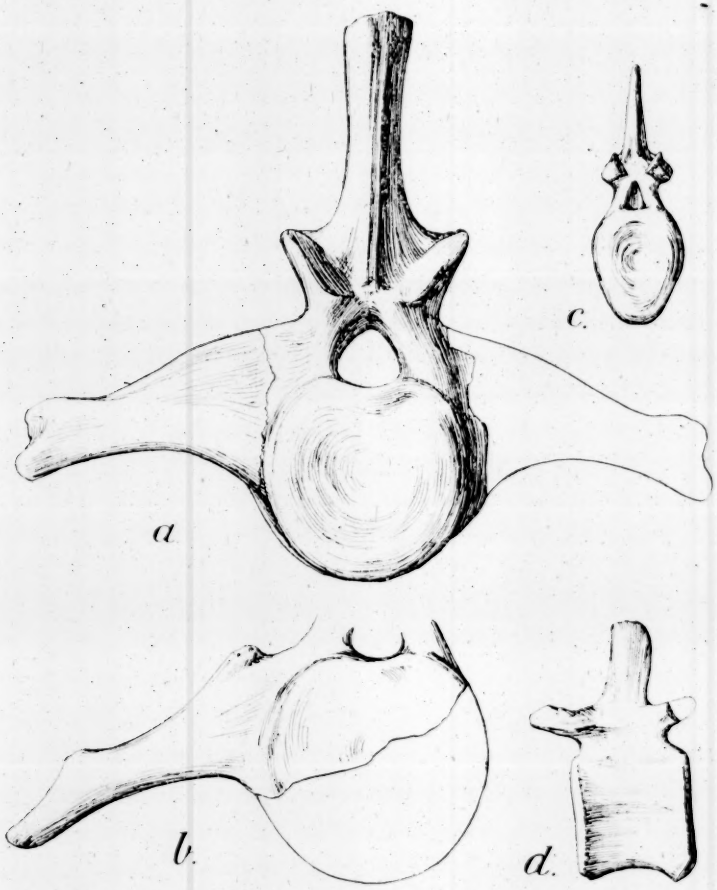


FIG. 3. *a*. First (?) caudal of *St. priscus*. *b*. Proximal caudal of the same. *c*. Anterior view of distal caudal. *d*. Lateral view of the same.

moderately short centra of these vertebræ are concave at both ends, more so posteriorly than in front; the sides are flat, the bottom keeled, the articular surfaces for the chevron bones large, equally developed at both ends, and nearly touching each other on the basal ridge. They are not easily distinguishable from the rugosities that occur round the

margin of the articular ends of the centra. The costoids in the middle of the tail are rod-like elements, decreasing rapidly in size backwards. There is a great resemblance to the middle caudal vertebræ in *St. ungulatus*.

The distal caudals in *St. priscus*, as shown in Figs. 3*c*, *d*, are still more elongate than the middle ones. The centrum is laterally compressed, as Fig. 3*c* shows, and exhibits a pentagonal section, with the point of the pentagon turned downwards. The articular surface for the chevron bone on these vertebræ is only developed at the posterior end. The concavity of the articular surface is also more marked at this end than at the other. The neural arch in these vertebræ, as in all the anterior ones, covers nearly the whole of the neural canal; the elongate rod-like prezygapophyses are comparatively feeble, their articular facets are directed as in the middle dorsals. The narrow neural spine (Fig. 3*d*) rises in a remarkable manner straight upwards; it is blade-like, tapering towards its summit, and, like the rest of this vertebra, it is characterized by the complete want of rugosities, thus indicating clearly that on this bone no great mass of firmly adhering tissue was present during life. This latter observation will prove to be of the utmost importance when we discuss the dermal armour of *St. priscus*.

The distal caudal in *St. priscus* differs from that of *St. ungulatus* and *Diracodon* by the feeble development of the neural spine, and still more by the development of elongate post-zygapophyses, for these are quite short and nearly sessile on the blade of the neural spine in *St. ungulatus*, *Diracodon*, and many other Dinosaurs, though not in *Polacanthus*. The development of the neural spine and the post-zygapophyses in *St. priscus* are features so strange for a posterior caudal that if the shape of the centra did not prove beyond all doubt the contrary, one might hesitate to refer this vertebra to an *Omosaurus*. The biconcave nature of all the caudals of our *Stegosaurus*, and the neural spines overlapping each other, do not imply great flexibility of this organ.

(To be concluded in our next Number.)

III.—Sedgwick Museum Notes.

New Crustacea from the Lower Greensand of the Isle of Wight.

By F. R. Cowper Reed, M.A., F.G.S.

(PLATE VII.)

AMONGST the large series of specimens of *Meyeria* recently obtained by the Sedgwick Museum, Cambridge, from the Lower Greensand of Atherfield, Isle of Wight, two new and strange forms, obviously referable to another genus, were detected by me in looking over the material. Their interest consists not only in belonging to new species but in representing the genus *Thenops*, of which the best known and only British species, so far described, is *Th. scyllariformis*, Bell, from the London Clay. There is one imperfect specimen in the British Museum from the Speeton Clay attributed (with a query) to *Thenops*, but no other British representative from the Cretaceous appears to have been found.

THENOPS CARTERI, sp. nov. (Pl. VII, Figs. 2, 2*a*.)

Description. Carapace elongated, narrowing anteriorly, divided at about half its length by cervical groove; median dorsal portion of carapace flattened, especially in thorax, with lateral portions bent down steeply on each side along tuberculated longitudinal lateral carinæ.

Cervical groove deep, strongly marked, divisible into (1) a short middle transverse portion slightly arched forwards and about one-fourth the width of the carapace at this level, and (2) a pair of lateral portions bent sharply forwards on each side and running out so as to meet the lateral carinæ at about 45°, outside which they bend down almost at right angles to inferior edge of carapace but turn forwards close to margin to meet it at an acute angle.

Posterior end of carapace concave in outline, and furnished with a narrow rounded ring with pitted surface marked off by a strong smooth furrow.

Cephalic portion of carapace with upper surface very gently convex, and defined on each side by slightly curved, fine lateral carinæ diverging backwards from rostral teeth to cervical groove, and marked by row of small sharply pointed tubercles increasing in size posteriorly.

Anterior end of cephalic portion abruptly truncate, furnished with median pair of short triangular rostral teeth somewhat flattened with their faces inclined inwards and their points about one-third the anterior width of the carapace apart. Median notch between rostral teeth rounded. Anterior edge of carapace outside rostral teeth simple, nearly straight, not excavated nor dentate, meeting lateral edges nearly at right angles. Median portion of cephalic region forming a slightly elevated sub-lanceolate pre-gastric area, ill-defined at the sides and behind where at about half the length of the cephalon it touches two sub-parallel, gently curved longitudinal rows of 6–7 spinose tubercles, bounding laterally the narrow, elongated, somewhat flattened gastric region reaching back to the cervical groove and having a width equal to about one-fifth that of the base of the cephalon.

A pair of low indefinite longitudinal ridges run back from the bases of the rostral teeth with a slight divergence to the level of the anterior end of the gastric region, where they end in somewhat marked depressions, prolonged outwards as weak grooves curving back to the lateral carinæ and marking off indistinctly on each side of the gastric region a sub-triangular area in front of the cervical groove. Outside the lateral carinæ of the cephalon the carapace is bent down, very slightly at the anterior end, but with increasing steepness posteriorly. Inferior edge of carapace thickened and armed with large closely set spinose tubercles.

Thoracic portion of carapace with upper part horizontally flattened, but medially somewhat elevated into cardiac region and bearing a longitudinal carina of large pointed tubercles. Cardiac region with slight independent swelling, about two-thirds the length of thorax and one-third its width, sub-lanceolate in shape and marked out on each side by weak furrows gently curved, but not defined behind. On each side of cardiac region thorax is flattened and horizontally

extended to the strong lateral carinæ, which are gently arched outwards and formed by a row of large sharply pointed tubercles directed forwards and increasing in size from the posterior margin of the carapace to the cervical groove. Outside these carinæ the sides of the thorax are bent down almost at right angles.

Surface of carapace ornamented with small, widely separated, sharply pointed tubercles. On the cephalon the tubercles are not numerous, and are irregularly distributed, or obscurely in longitudinal series; on the thorax the tubercles are larger and arranged on the upper flattened portion at equal distances apart in fairly distinct longitudinal lines parallel to the lateral carinæ, but on the steeply inclined sides they are less regularly placed and are more closely aggregated immediately behind the cervical groove.

The large tubercles of the median and lateral carinæ are conical and sharp with the points directed forwards.

Second antennæ composed of large flattened and ridged joints (only part of one joint on the left side is preserved).

Abdomen gently convex, broad; surface of terga flat, but bearing a thin elevated longitudinal median carina; lateral edges of terga slightly thickened; surface of shell densely but finely pitted. Epimeres becoming successively longer and sub-falcate; epimere of second segment sub-quadrate in shape, wider than long, with straight lower edge and swollen band on anterior margin, ending above in articulating peg to fit into socket of preceding segment. Epimeres of third and fourth segments longer than wide, sub-falcate, anterior and lower margins forming a continuous curve, and posterior edge serrated; upper anterior corner swollen and cut off by oblique furrow and projecting as articulating peg; surface of shell finely pitted, but less densely than rings. Peræopods compressed, slender, with surface smooth and sparsely pitted.

Dimensions.

	mm.
Length of carapace along median line to rostral notch	33·5
Length of thorax along median line	17·0
Width of thorax between lateral carinæ at posterior end	17·0
Width of thorax at point of section of lateral carinæ by cervical groove	13·5
Width of head at anterior end between outer lateral angles	16·0
Width of abdomen	16·0

Holotype. Carapace with portion of one of the right peræopods, one joint of left second antennæ, and with four segments of abdomen attached. From the Lower Greensand, Atherfield, Isle of Wight.

Affinities. This species is undoubtedly allied to the London Clay form *Thenops scyllariformis*, Bell.[1] The peculiar flattening of the upper part of the carapace, the sharply bent down lateral portions, the lateral and median carinæ, the general development of the gastric and other regions, the pair of rostral teeth, and the simple straight anterior edge of the carapace are features in common. There are, however, certain obvious differences which a comparison with the large series of splendidly preserved examples of *Th. scyllariformis* from Portsmouth

[1] Bell, Mon. Foss. Malac. Crust. (Palæont. Soc.), 1857, p. 33, pl. vii, figs. 1–8.

in the Sedgwick Museum clearly brings out. In the first place the thorax of the London Clay form has its sides nearly parallel; the lateral carinæ are less-marked; the cephalic part of the carapace is shorter and broader; the anterior lateral angles are produced forwards into stout spinose processes; the cervical groove is not divisible into three parts, but forms a continuous gentle curve meeting the lateral carinæ less acutely; the hepatic depressions are deeper and larger; the gastric region is lyre-shaped, and there is a prominent large median tubercle just in front of it; the abdomen is less convex and the surface of the segments is much more coarsely and closely pitted, and the median ridge rises into a stout tubercle; and, finally, the tubercles on the general surface of the carapace are low and rounded or transverse.

Our new species may be appropriately dedicated to the late Dr. Carter.

The Lower Senonian species known as *Podocrates dülmensis* (Beeks MS.)[1] is closely related in many respects to *Th. Carteri*, but differs by having the orbits excavated and the anterior margin of the carapace toothed; the tubercles around and in front of the gastric region are differently disposed; the lateral carinæ of the thorax are not regularly arched outwards; the cervical groove is more gently and regularly curved; there are fine oblique furrows on the steep sides of the carapace; the tubercles on the carinæ and carapace generally are rounded and not sharply pointed; the abdomen has a median tubercle and a pair of lateral ones instead of a longitudinal keel, and the rings are not pitted.

In spite of Schlüter's[2] contention that *Podocrates*, Beeks MS., 1850,[3] is synonymous with *Thenops*, Bell, 1857 (op. cit.), there seems reason to doubt it, on account of the orbits in the former being excavated and the anterior margin toothed, whereas in *Thenops* the anterior edge of the carapace on each side of the rostral teeth is straight, simple, and not indented or toothed. For this reason it appears desirable to place our new species from Atherfield in the genus *Thenops*, which has *Th. scyllariformis* as its type.

Thenops tuberculatus, sp. nov. (Pl. VII, Figs. 1, 1*a*, 1*b*.)

Description. Carapace elongated, narrowing anteriorly, divided transversely into two unequal parts by cervical groove; median dorsal portion of carapace flattened; lateral portions sharply bent down on each side along obscure lateral carinæ curving down somewhat posteriorly.

Cervical groove strong, smooth, consisting of three parts—(1) a short transverse median portion about one-fourth the width of the carapace at this level, and (2) a pair of lateral portions bending forward sharply and running in a slightly sigmoidal course to meet the lateral carinæ at about 45°, outside which they bend down and cross the sides at right angles.

Posterior end of carapace strongly concave in outline, with lateral

[1] Schlüter, Zeitschr. deut. geol. Gesell., Bd. xiv, p. 713, t. xii, figs. 1–3, 1862.
[2] Ibid., p. 710; id. op. cit., Bd. li, pp. 409–30, 1899.
[3] Geinitz, *Die Quadersandstein*, 1850, t. ii, fig. 6 (no description).

angles somewhat produced backwards and pointed, and with a narrow rounded tuberculate ring marked off by a smooth furrow.

Cephalic portion of carapace gently convex between lateral carinæ, which converge anteriorly and end just outside base of rostral teeth. Lateral carinæ marked by specially large tubercles posteriorly, decreasing in size anteriorly. Median portion of cephalon gently swollen into obscurely defined sub-lanceolate pre-gastric area passing back imperceptibly into gastric region, which is marked in front by a pair of specially large tubercles situated rather behind the middle of the cephalon. Gastric region narrow, somewhat depressed, oblong defined on each side by irregular row of rather large tubercles running back to cervical furrow. A weak depression lies on each side of the anterior pair of gastric tubercles and is prolonged outwards into a weak furrow curving slightly back to the point where the cervical furrow crosses the lateral carinæ. Rostral teeth triangular (imperfectly preserved), separated by sharply rounded notch, with their faces flattened and inclined inwards. A narrow indistinct post-rostral ridge, marked by a few large tubercles, decreasing in size posteriorly, runs back from the base of each rostral tooth to the depressions (hepatic) on each side of the gastric region. Anterior edge of lateral portions of carapace not preserved. Sides of cephalon posteriorly bent down at right angles to upper surface along lateral carinæ.

Surface of cephalon ornamented with sharply pointed, conical tubercles smaller and fewer than on thorax and less closely placed, but tending to be arranged in longitudinal lines especially towards the lateral carinæ.

Thorax horizontally extended and flattened dorsally between lateral carinæ, with median portion somewhat elevated and provided with median longitudinal keel bearing a row of specially large, sharply conical tubercles. Lateral portions of thorax bent down at right angles to upper portion without the formation of definite lateral carinæ posteriorly, but anteriorly towards cervical groove the angular line of bending is marked by definite line of large conical tubercles. Sides of thorax decrease in height posteriorly owing to lateral line of bending curving down behind. Cardiac region gently elevated and defined by pair of weak smooth furrows, gently curved outwards and reaching two-thirds the length of the thorax; width of cardiac region across middle about one-third that of thorax. Anterior margins of thorax swollen slightly on each side behind and along cervical groove into a low rounded ridge, widening a little laterally to the lateral carinæ against which it ends.

Surface of thorax covered with large, sharply pointed, conical tubercles, mostly of equal size and closely placed, but not in any determinable order; on the sides these bases are nearly or quite contiguous. Both the large tubercles on the carinæ and those on the general surface of the carapace have their sharp points slightly arched and directed forwards.

Abdomen strongly arched from side to side (five segments preserved); tergum with general surface flat, and with a thin median longitudinal keel; shell covered with small equal-sized numerous pits. Inferior lateral edges of terga somewhat thickened. Epimeres of

second to fifth segments sub-triangular to sub-falcate, with anterior and inferior margins forming a continuous curve and posterior margin dentate. Small triangular area cut off by short furrow from anterior upper corner and swollen into peg for articulation.

Peræopods slender, laterally compressed, with smooth surface sparsely dotted with pits.

Dimensions.	mm.
Length of carapace along median line to rostral notch	29·0
Length of carapace along median line to level of posterior lateral angles	33·5
Length of thorax along median line	14·0
Width of thorax posteriorly between lateral carinæ	18·0
Width of carapace at point of section of lateral carinæ by cervical groove	13·0
Distance between outer edges of bases of rostral teeth	6·5
Width of abdomen	14·5

Holotype. Carapace with five segments of abdomen attached and portions of three peræopods on right side. From the Lower Greensand, Atherfield, Isle of Wight.

Affinities. This species differs from *Th. Carteri* in the more elongated carapace, the smaller development of the lateral keels and their downward curvature posteriorly, the much closer and coarser tuberculation of the surface, the different kind of demarcation of the gastric region, the stronger ridges running back from the bases of the rostral teeth, and in the more convex abdomen. But the most striking differences amongst those above-mentioned are the general shape and tuberculation.

With *Th. scyllariformis* it agrees more closely than does *Th. Carteri* in the development of the post-rostral ridges and in the smaller prominence of the lateral carinæ. But otherwise it has fewer points of resemblance. With *P. dulmensis* the development of the large gastric tubercles is a feature in common, but it is less closely allied to this Senonian species in general characters than is *Th. Carteri*.

From the possession of a coarsely tuberculate surface it may be approximately designated by the specific name *tuberculatus*.

EXPLANATION OF PLATE VII.

Fig. 1. *Thenops tuberculatus*, sp. nov. $\times\frac{3}{2}$. Viewed from above.
,, 1*a*. Ditto. $\times\frac{3}{2}$. Viewed from right side.
,, 1*b*. Ditto. $\times\frac{3}{2}$. Viewed from left side.
,, 2. *Thenops Carteri*, sp. nov. $\times\frac{3}{2}$. Viewed from above.
,, 2*a*. Ditto. $\times\frac{3}{2}$. Viewed from right side.

(Both specimens are from the Lower Greensand, Atherfield, Isle of Wight.)

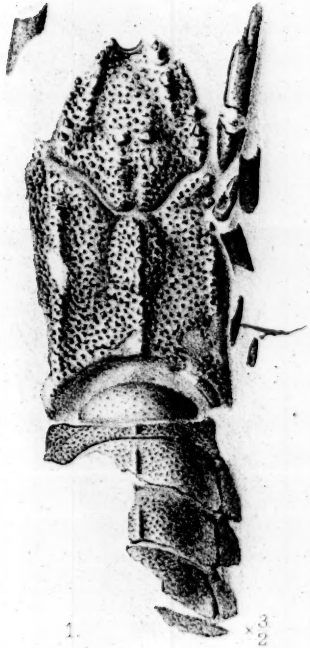
IV.—On the Formation of a Laterite from a practically Quartz-free Diabase.

By Professor J. B. Harrison, C.M.G., M.A., F.G.S., F.I.C.

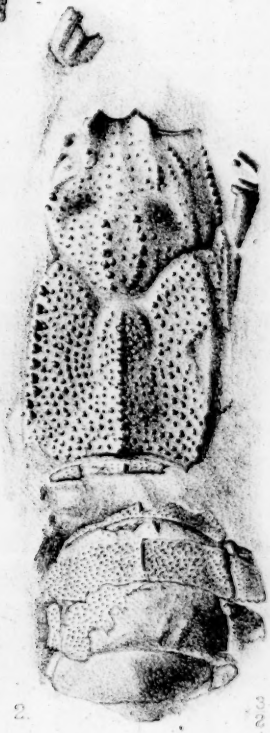
AFTER I had forwarded the paper on "The Residual Earths of British Guiana commonly termed 'Laterite'", published on pp. 439–52, 488–95, and 553–62 of the Geological Magazine for October, November, and December, 1910, I visited the neighbourhood of Christianburgh and Akyma on the Demerara River in British Guiana and examined a small long-deserted quarry in a very fine-grained

1a.

1b.



1. $\times\frac{3}{2}$



2. $\times\frac{3}{2}$

2a

A. H. Searle del. et lith. West, Newman imp.

New Species of Thenops.

diabase intrusive in hornblende-granitite-gneiss near the latter place. I obtained from the lateritic earth lying on the mass of unaltered diabase a boulder of that rock in which the central parts were ideally fresh, whilst the outer parts were decomposed into laterite. I separated these parts with great care into an outer red one, apparently an ordinary ferruginous laterite, and an inner one, buff-coloured with whitish spots in it, which was in actual contact with the unaltered rock. When I obtained the boulder these crusts were quite soft, but after a few days' exposure to the air they hardened considerably.

The diabase of the boulder and its crusts of laterite were analysed by Mr. Reid and myself with the following results:—

	Diabase.	Laterite.	
		Inner crust.	Outer crust.
Quartz	·03	9·38	7·73
Combined Silica	51·06	7·56	4·80
Aluminium Oxide	15·70	34·11	40·33
Iron Peroxide	1·68	20·88	18·28
Iron Protoxide	8·57	3·75	3·84
Magnesium Oxide	7·74	·94	·27
Calcium Oxide	9·11	·84	·10
Sodium Oxide	2·38	·65	·54
Potassium Oxide	1·55	·23	·24
Water (combined)	·35	17·96	19·90
Titanium Oxide	1·70	4·09	4·32
Phosphoric Anhydride	minute trace	trace	trace
Manganese Oxide	·41	*nil*	*nil*
	100·28	100·39	100·35

The chemical composition of the diabase indicated that it should not contain quartz, but as I was desirous of ascertaining directly whether or not the rock contained any quartz I treated some of it in a very finely divided state by Laufer's method (fusion with microcosmic salt). I found by this method that the proportion of silica present in the form of quartz was practically negligible—·03 of 1 per cent. The diabase is therefore practically quartz-free.

The mineralogical compositions of the diabase and of its concentric lateritic crusts may be shown as follows:—

	Diabase.	Laterite.	
		Inner crust.	Outer crust.
Quartz	·03	9·4	7·7
Orthoclase	9·2	1·4	1·4
Plagioclase	47·6	9·7	5·1
Pyroxene	33·8		
Olivine, Serpentine, and Talc	4·1	2·2	·5
Magnetite	2·4	·1	*nil*
Ilmenite	3·2	7·8	8·2
Hæmatite		12·3	17·7
Limonite		9·2	
*Bauxite		47·8	58·9
	100·33	99·9	99·5
(Diaspore			2·5
*(Gibbsite		47·8	56·4
*Alumina in Bauxite		31·3	39·0

These represent the passage of a normal, practically quartz-free, diabase into a laterite of aluminium hydrate and iron ores, both residuary and secondary, from the ferromagnesian minerals, with some quartz, but without any kaolin. The finely divided quartz was separated from the laterite by long-continued boiling with sulphuric acid, and also by solution of the laterite in dilute hydrochloric and hydrofluoric acids. The residues were examined microscopically in both cases, and proved to consist only of quartz.

The analyses when calculated to a titanium oxide constant basis throw somewhat interesting light on the changes which have taken place during the conversion of the diabase into laterite. The results are shown in the following :—

	Diabase.	Laterite.	
		Inner crust.	Outer crust.
Quartz	·03	3·90	3·04
Combined Silica	51·06	3·14	1·89
Aluminium Oxide	15·70	14·16	15·87
Iron Peroxide	1·68	8·68	7·59
Iron Protoxide	8·57	1·56	1·51
Magnesium Oxide	7·74	·39	·10
Calcium Oxide	9·11	·35	·04
Sodium Oxide	2·38	·27	·21
Potassium Oxide	1·55	·09	·09
Water (combined)	·35	7·45	7·83
Titanium Oxide	1·70	1·70	1·70
Phosphoric Anhydride	minute trace	trace	trace
Manganese Oxide	·41	*nil*	*nil*
	100·28	41·69	39·87

The proximate mineralogical compositions calculated on the same basis fairly well illustrate the changes in the constituent minerals of the diabase during its conversion into laterite, and are as follows :—

	Diabase.	Laterite.	
		Inner crust.	Outer crust.
Quartz	·03	3·9	3·0
Orthoclase	9·2	·6	·6
Plagioclase	47·6	4	2·0
Pyroxene	33·8	*nil*	*nil*
Olivine, Serpentine, and Talc	4·1	·9	·2
Magnetite	2·4	·1	*nil*
Ilmenite	3·2	3·2	3·2
Hæmatite		5·1	7·0
Limonite		3·8	
Bauxite		19·8	23·2
	100·33	41·4	39·2
Diaspore			1·0
Gibbsite		19·9	22·2
Alumina in Bauxite		12·9	15·3

The chemical compositions of the diabase and of the outer crust or laterite derived from it when calculated on a titanium oxide constant basis show changes in the following constituents :—

	Gain.	Loss on each Constituent. Amount.	Per Cent.
Quartz	3·01		
Combined Silica		49·17	96·3
Aluminium Oxide	·17		
Iron Peroxide	5·91		
Iron Protoxide		7·06	81·2
Magnesium Oxide		7·64	98·7
Calcium Oxide		9·07	99·5
Sodium Oxide		2·17	91·2
Potassium Oxide		1·46	94·2
Water	7·48		
Manganese Oxide		·41	100

The loss on the total silica is not as high as that shown on the combined silica, as part of the latter has been changed to quartz, the loss on the total silica being 46·16 parts out of 51·09, equivalent to 90·3 per cent. of that substance. Similarly, the loss on the ferrous iron is to some extent set off by a gain in ferric iron, the actual loss of the oxides of iron being 1·74 parts out of 10·29, or 16·9 per cent. The loss of all constituents of the original diabase amounts to 68·2 per cent., and this loss is accompanied by a gain of 7·40 per cent. of water and of ·59 of 1 per cent. of oxygen, so that the decomposition of 100 parts of diabase has resulted in the formation of 39·9 parts of a bauxitic or aluminous laterite.

The position and mode of the exposure of the diabase, a small boss intrusive in a coarse-textured hornblende-granitite-gneiss, indicates that the lateritization is of comparatively recent origin; and it is noticeable that the action is simple, consisting only of such changes as could be produced by the long-continued action of percolating water. The action has taken place above the water-table, and the removal of combined silica from the bases present has been very complete; as far as analytical determinations show, none of it having been retained in combination as kaolin. The outer crust differs from the inner one by its lesser contents of the iron oxides and their lower state of hydration, and to a slight extent by the lower hydration of the aluminium hydrate. If by continued action of water containing readily oxidizable organic matters the iron oxide, other than that present in ilmenite, of the outer crust were removed, a laterite containing over 70 per cent. of aluminium hydrate would result.

V.—Notes on some Upper Devonian Arthrodira from Ohio, U.S.A., in the British Museum (Natural History).

By L. Hussakof, Ph.D., Associate Curator of Fossil Fishes in the American Museum of Natural History.

(PLATE VIII AND THREE TEXT-FIGURES.)

SOME years ago the British Museum acquired from Dr. William Clark a collection of the remarkable Arthrodira found by him in the Upper Devonian shales of Ohio. In this material there are several specimens which were described as new before being brought to Europe, but concerning which there has been more or less doubt among students of the Arthrodira. Hitherto, however, it has been

quite impossible to dispel this doubt since the material necessary to a comparative study of the forms in question is to be found only in America. Last year I enjoyed the privilege of going over this material in the British Museum, thanks to the courtesies extended to me by Dr. Arthur Smith Woodward, F.R.S., the Keeper of Geology, and as I had just come from a study of the American forms I was in a position to resolve these doubtful cases. The results of this study are presented in the following pages.

1. The so-called genus Brontichthys.

The name *Brontichthys* was proposed by Claypole in 1894[1] for a large imperfectly preserved mandible having considerable resemblance to that of *Titanichthys*. The type species he named *Brontichthys Clarki*, in honour of the collector, Dr. William Clark. Clark himself subsequently applied the name *Brontichthys*, in manuscript, to a pair of small mandibles which he had found associated with some other remains in a small concretion. Plaster casts of this specimen have found their way into most of the larger museums, and the original itself is in the British Museum (P. 9332).

Fig. 1. Mandible of *Titanichthys* sp. Type of *Brontichthys Clarki*, Claypole. × $\frac{1}{2}$. Brit. Mus., P. 9298. Cleveland Shale (Upper Devonian): Ohio.

It is obvious that the validity of the genus *Brontichthys* depends upon the type which was described by Claypole, and only secondarily upon the specimen named by Clark. The former, as stated above, is a large, imperfect mandible (British Museum, P. 9298). A figure of it is given above (Fig. 1). On careful examination it is seen to be a mandible of *Titanichthys*, rather crushed and defective in the anterior extremity—which fact misled Claypole, who regarded it as representing a new genus. It also lacks the posterior extremity.

As to Clark's specimen (Pl. VIII, Fig. 2): this consists of a small block of shale containing a pair of small mandibles, two crushing plates apparently of the upper jaw and not well preserved, and one or two fragments. On close examination the mandibles are seen to pertain to a young individual of *Mylostoma variabile*, Newberry. At the time Clark applied the name *Brontichthys* to them, only a few mandibles of *Mylostoma* were known, namely, those figured by Newberry in his *Paleozoic Fishes of North America*; and these were all larger and heavier than Clark's specimen, so that the latter might then have been looked upon as of a different genus. At the present day, however, several small mandibles of *Mylostoma* are available with which Clark's specimen may be compared.

[1] "On a new Placoderm, *Brontichthys Clarki*, from the Cleveland Shale": *Amer. Geologist*, vol. xiv, pp. 379–80, pl. xii. "On a new gigantic Placoderm from Ohio": Third Ann. Rep. Ohio State Acad. Sci., 1895, pp. 8–9.

They agree well, for instance, with the pair of mandibles figured by Dean[1] in the specimen showing the associated head and body plates (American Museum, No. 7526); they are somewhat smaller than the latter. They may also be compared with a juvenile *Mylostoma* mandible in the American Museum (No. 3588). Indeed, there can be no doubt that the specimen which Clark referred to Claypole's genus *Brontichthys* belongs to *Mylostoma*.

From all this it follows that *Brontichthys* is not a valid genus but merely a synonym of *Titanichthys*.

2. Titanichthys rectus, Claypole.

1893. *Titanichthys rectus*, Claypole, Geol. Surv. Ohio, vol. vii, p. 609, pl. xlii, fig. 5.

This species was figured and named, but not sufficiently described. It is, however, a good species. The type is a mandible, 23 inches long (Fig. 3), in the collection of the British Museum (P. 9328). It may be briefly described as follows: Mandible as large as that of *Titanichthys Clarki*, but almost straight fore and aft. Anterior functional portion relatively smaller than the corresponding region in other species of the genus, and not drawn out into an elongate spatulate process, but gradually decreasing in depth to the extremity.

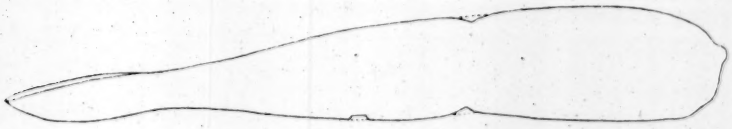


Fig. 3. *Titanichthys rectus*, Claypole. Mandible in inner aspect. × $\frac{1}{6}$. Type. Brit. Mus., P. 9328. Cleveland Shale (Upper Devonian): Ohio.

The species of *Titanichthys* at present recognizable are four in number—

T. Agassizi, Newberry, Trans. N.Y. Acad. Sci., vol. v, p. 27, 1885.
T. Clarki, Newberry, ibid., vol. vi, p. 164, 1887.
T. attenuatus, Claypole, Rep. Geol. Surv. Ohio, vol. vii, p. 612, pl. xlii, figs. 1, 2, 1893.
T. rectus, Claypole, ibid., p. 609, pl. xlii, fig. 5, 1893.

3. Selenosteus brevis (Claypole). (Pl. VIII, Fig. 4.)

1896. *Titanichthys brevis*, Claypole, Amer. Geologist, vol. xvii, p. 166, pl. x.
1910. *Selenosteus Kepleri*, Dean, Mem. N.Y. Acad. Sci., vol. ii, p. 94, pls.

One of the two cotypes of *T. brevis*, Claypole, has been identified by the writer in the British Museum Collection (P. 9330). It consists of a small slab (Pl. VIII, Fig. 4), 23 by 25 cm., with its counterpart and several fragments which apparently formed part of the original concretion. It exhibits both mandibles (*Md.*), the median occipital (*MO.*), and a fragment from the lateral margin of the head (*Cran.*), the clavicular (*Cl.*), and two or three other plates. The mandibles represent a small species, smaller than any *Titanichthys* known. It was this circumstance that led Claypole to name it *T. brevis*.

On a careful study of the mandibles it is seen that they do not belong to the genus *Titanichthys*, but to *Selenosteus*. They are similar

[1] Mem. N.Y. Acad. Sci., vol. ii, p. 101, 1910.

to those figured by Dean[1] in the type of *S. Kepleri*, except for defects in preservation, having lost their anterior extremities and the minute denticles. They differ considerably in form from the mandible figured in inner and outer aspect by Claypole in his original description, but it is impossible to say to what extent his figure is a restoration. His figures of this species are not very accurate, missing parts being restored with too much certainty and in most cases not being indicated by dotted lines. The cranium is drawn from disarticulated plates as if it were a complete specimen, and is altogether too pointed and drawn out in front. The anterior dorso-lateral is also partly restored, the posterior part being, as he says, "somewhat restored and may not be quite true to nature."

In the specimen in the British Museum (Pl. VIII, Fig. 4) the median occipital plate displays the inner aspect and closely resembles the corresponding element in *S. Kepleri*.[2] The clavicular, which was described by Claypole as a suborbital, is also preserved. It agrees exactly with the one figured by Dean.[3]

From these facts it appears that *T. brevis*, Claypole, is identical with *S. Kepleri*, Dean. The amended name of the species is *S. brevis* (Claypole).

4. Stenognathus Gouldi (Newberry). (Pl. VIII, Fig. 5, and Text-figure, Fig. 6.)

1885. *Dinichthys Gouldii*, Newberry, Trans. N.Y. Acad. Sci., p. 26.
1889. *D. Gouldii*, Newberry, Paleoz. Fishes, p. 150, pl. ix.
1889. *D. corrugatus*, Newberry, ibid., p. 151, pl. vii, figs. 3, 3*a*.
1893. *D. gracilis*, Claypole, Amer. Geologist, vol. xii, p. 279, fig.
1896. *D. Gouldi*, Newberry (ed. Dean), Trans. N.Y. Acad. Sci., vol. xv, p. 157, pl. vii.
1897. *Stenognathus corrugatus*, Newberry (ed. Dean), ibid., vol. xvi, p. 30, pl. xxiv, figs. 27, 28.
1908. *Dinichthys Gouldi*, Newberry, Hussakof, Bull. Amer. Mus. Nat. Hist., vol. xxv, p. 8, fig. 1.
1909. *Stenognathus corrugatus*, Hussakof, ibid., vol. xxvi, p. 267, fig. 4.

The writer has recently shown (1909) that the mandibles described under the names *S. corrugatus* by Newberry and *D. gracilis* by Claypole are the same, and that the genus *Stenognathus* should stand as distinct from *Dinichthys*. In the British Museum there is a specimen (P. 9335) which shows a pair of similar mandibles, and associated with them a number of disarticulated elements of the same individual, including the cranium, suborbital, maxillary, premaxillary, and several dorsal and ventral armour plates. This specimen is, therefore, of especial interest since it acquaints us for the first time with the head and body armour of the form known as *Stenognathus*. Furthermore, there are two elements in this specimen, the premaxillary and the suborbital, which are of quite distinctive form and may be told at a glance from the same elements in other Dinichthyids; and by reason of this very distinctiveness of form these elements are seen to agree closely with the corresponding ones in the specimen which was described by Newberry as *D. Gouldi*. The mandibles of the latter were represented

[1] Mem. N.Y. Acad. Sci., vol. ii, pl. vi, fig. 36.
[2] Ibid., pl. vi, fig. 33, *MO*.
[3] Ibid., fig. 38.

only by two small fragments, the anterior point of one and the posterior end of the other; and these, as far as one may judge from such fragments, indicate a very slender type of mandible quite like that of *Stenognathus*, and thus strengthen the view that *D. Gouldi* belongs in the genus *Stenognathus*.

The specimen in the British Museum is shown in the photograph (Pl. VIII, Fig. 5) and in the outline figure in the text (Fig. 6). The cranium (*Cran.*) is shown from the inner aspect. It is of about the same size as that of *D. Gouldi*. It is too imperfectly preserved to show much of the detail except the pineal foramen. The eyes in this species must have been of quite extraordinary size.

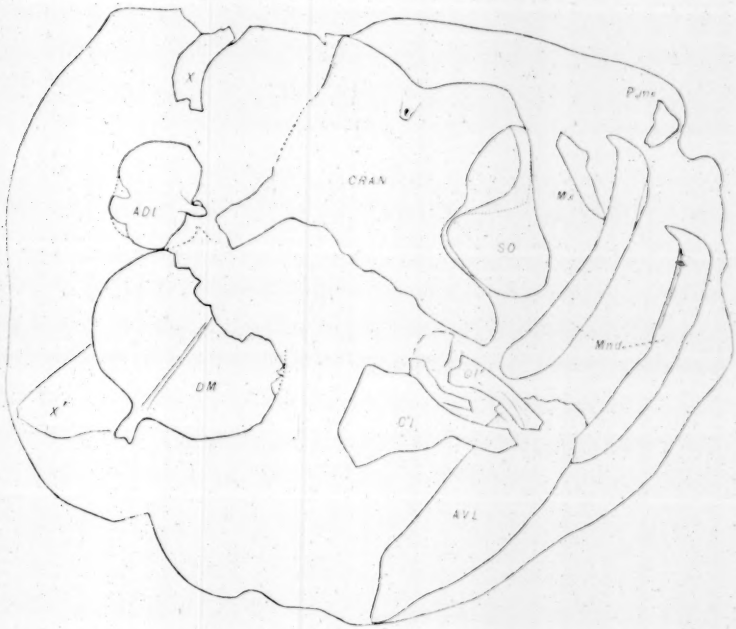


FIG. 6. Outline of bones of *Stenognathus Gouldi* (Newb.), exposed on slab shown in Pl. VIII, Fig. 5 (Brit. Mus., P. 9335). Cleveland Shale (Upper Devonian); Ohio. Explanation of letters on bones: *ADL.* anterior dorso-lateral; *AVL.* anterior ventro-lateral; *Cl., Cl'.* clavicular (imperfect); *Cran.* cranium, inner aspect, and showing the pineal foramen; *DM.* dorso-median; *Mnd.* mandibles, the left in inner view, the right in outer; *Mx.* left maxilla, outer view; *P.mx.* left premaxilla, inner view; *SO.* suborbital; *x, x'.* fragmentary plates.

The suborbital (*SO.*) agrees entirely with the one figured by Newberry in *D. Gouldi* in his *Paleozoic Fishes of North America*, pl. ix, fig. 4.

The clavicular (*Cl.*), which is incomplete in the specimen, is somewhat different from the same element in *Diniehthys*, emphasizing the generic distinctness of this form.

The dorso-median (*DM.*) resembles the one in Newberry's specimen; but since the latter, like the one in the present specimen, lacks the

anterior portion, it is impossible to compare it with Newberry's in detail. The two seem to be of about the same size.

The anterior dorso-lateral (*ADL.*) is shown in ventral aspect, and is not well preserved at the sides. It does not differ from the same element in *Dinichthys*.

The jaw elements are represented by both mandibles (*Mnd.*), the left maxilla (*Mx.*), and the left premaxilla (*P.mx.*). The mandibles are of the typical stenognathous form, that is to say, greatly elongated and very slender. The left is shown in inner aspect and the right in outer. The maxillary has a cutting edge corresponding to the elongated cutting portion of the mandible. The premaxillary is shown in inner view; it agrees almost exactly both as to size and form [1] with the corresponding element figured by Newberry in his *D. Gouldi*.

Hence it appears that the specimen which has been described as *D. Gouldi*, and the mandibles which have been described as *Stenognathus corrugatus* and *D. gracilis*, really belong to one and the same species. This should be known as *S. Gouldi*, the specific name *Gouldi* having priority.

EXPLANATION OF PLATE VIII.

Fig. 2. Small slab exhibiting a pair of mandibles, two upper dental plates (the dark elements seen in front of the mandibles) and fragments, of a small specimen of *Mylostoma*, named, in manuscript, by Dr. William Clark, *Brontichthys*. × ½. Brit. Mus., P. 9332. Cleveland Shale (Upper Devonian): Ohio.

Fig. 4. *Selenosteus brevis* (Claypole). Type of *Titanichthys brevis*; slightly less than × ½. Brit. Mus., P. 9330. Cleveland Shale (Upper Devonian): Ohio. *AVL.* anterior ventro-lateral; *Cl.* clavicular; *Cran.* left half of cranium, seen from within; *Mnd.* mandibles; *MO.* median occipital element of cranium, from within.

Fig. 5 and outline, Text-fig. 6. *Stenognathus Gouldi* (Newb.). Slab showing disarticulated plates of one individual. × ½. Brit. Mus., P. 9335. Cleveland Shale (Upper Devonian): Ohio.

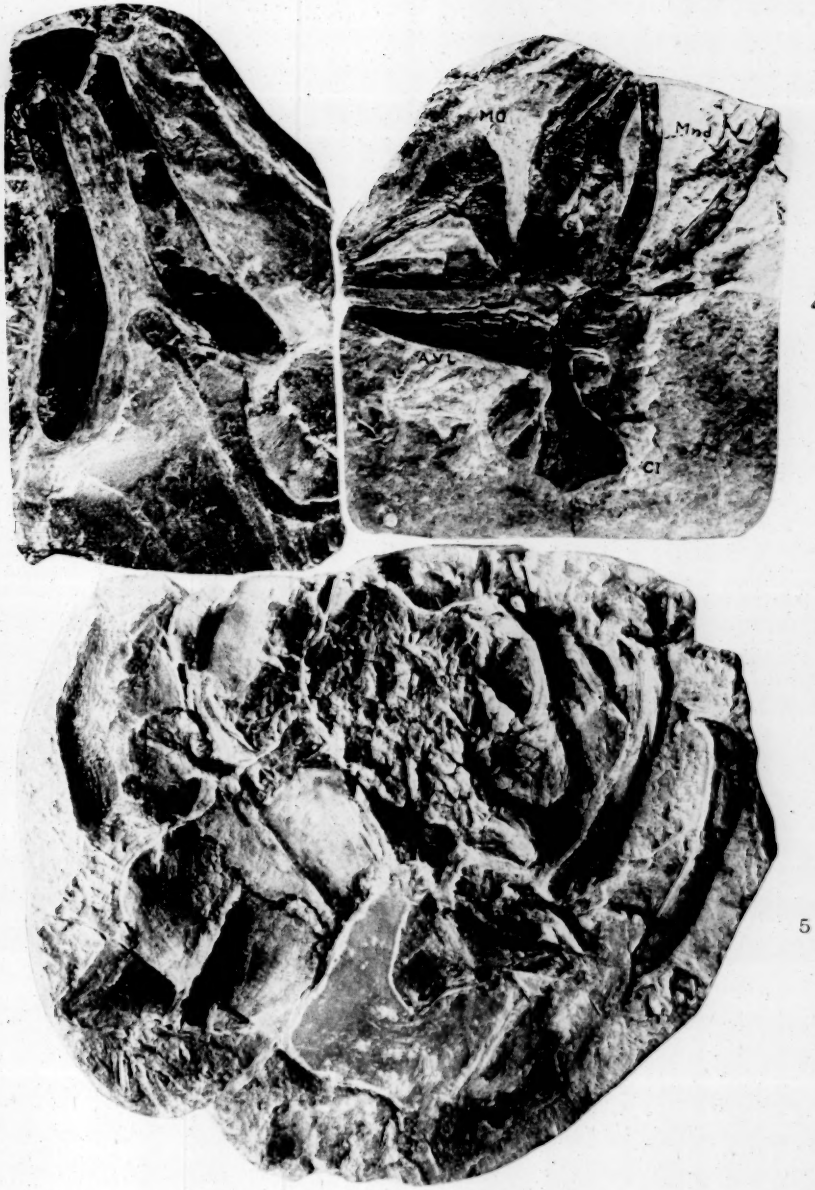
REVIEWS.

I.—The Palæontographical Society.

THE Palæontographical Society's volume for 1910, which was issued at the end of January, 1911, contains instalments of the monographs of Carboniferous and Chalk Fishes, Cretaceous Lamellibranchs, and British Graptolites, besides a small complete monograph of British Carboniferous Arachnida. It is illustrated in the usual sumptuous style by twenty-eight plates, some prepared by lithography, others by collotype process.[2] Dr. Traquair's new part of Carboniferous Palæoniscidæ is especially welcome, and the text is now as far advanced as the plates. After completing the description of *Cycloptychius*, it deals with the numerous species of *Rhadinichthys*. A new restored figure of *R. ornatissimus* is given; and Mr. James Green's

[1] In Newberry's *Paleozoic Fishes of North America* (pl. ix, fig. 2), this element is figured in outer view, but not quite correctly. It represents a second cusp which in reality does not pertain to the specimen, but is an adherent superimposed fragment. The line from the point of the tooth to the postero-lateral termination of the element is gently convex, but quite smooth.

[2] And the text-figures are very numerous throughout the volume.



Upper Devonian Arthrodira from Ohio, U.S.A., in the British Museum (Nat. Hist.).

drawings of the various fossils are supplemented by useful enlarged sketches of scales by Dr. Traquair himself. Dr. Smith Woodward's contribution this year treats of very fragmentary fish-remains from the English Chalk, chiefly Chimæroid jaws and Selachian teeth, but it will prove invaluable to collectors of these fossils. It is illustrated by lithographs by Mr. A. H. Searle, and there are the usual explanatory text-figures by Miss G. M. Woodward. The comparison of the Cretaceous *Scapanorhynchus* with the existing *Mitsukurina* from Japanese seas is especially interesting. Mr. Henry Woods' monograph of Cretaceous Lamellibranchia now enters upon an account of *Inoceramus*, which is most profusely illustrated by Mr. Brock and supplies a long-felt want. The species are so numerous that those of the Chalk itself are scarcely reached in the new part, and we still eagerly await the next instalment, for which the material must now be almost overwhelming and need much study. Of the monograph of British Graptolites there is a large section, and it suffices to note that Miss Elles and Mrs. Shakespear attain their usual standard of excellence. The enlarged drawings, as before, are placed in the text, while figures of the natural size, which can be examined by a lens, occupy the collotype plates. Mr. R. I. Pocock's small complete monograph of the Terrestrial Carboniferous Arachnida of Great Britain, illustrated by numerous text-figures and three lithographic plates by Miss G. M. Woodward, is a noteworthy contribution to the volume. Mr. Pocock has industriously amassed material from all collections, and the result is truly astonishing. Much progress has been made during recent years in the discovery and description of Palæozoic Arachnids, and the restored figures which Mr. Pocock is now able to publish of several species are especially novel and interesting.

The Palæontographical Society is to be congratulated on the manner in which it continues to perform its double function of enabling stratigraphers to name their fossils, and of providing material for zoologists to compare living and extinct organisms. Subscribers appear still to be fewer than the Society needs for its full activities, and some of the plates in the new volume have been paid for by the Carnegie Trust for the Universities of Scotland. All who are interested should communicate with the Secretary, Dr. A. Smith Woodward, British Museum (Nat. Hist.), South Kensington, S.W.

II.—Extinct Monsters and Creatures of other days. By the Rev. H. N. Hutchinson, B.A., F.R.G.S., F.G.S., F.Z.S. New edition. pp. xxxiv and 330, with 55 plates and 113 text-figures. London: Chapman & Hall, 1910.

ALTHOUGH to the trained scientific observer all fossil animal- or plant-remains are interesting, it is not so with the ordinary Museum-visitor, for size and a certain resemblance to living animals appeal more to the popular imagination than incomprehensible or diminutive structures. These are the points that led Mr. Hutchinson some years ago to publish his well-known book on extinct monsters, and the necessity of bringing out a third edition showed that to his and to his publishers' great joy he had not failed

to find numerous readers. Of course, the magnificent collections of the Natural History Museum facilitated this undertaking, and it is a pleasure to remark that this unique treasure-house is often referred to in the new edition.

In a review of Hutchinson's book in a scientific journal we must not look at this work merely from the evidently satisfactory commercial and general point of view, but must consider if the author has succeeded in moulding modern science into a popular form, and thus must look for the faults as well as for the merits of the work we are reviewing.

Considering the difficulty that has to be overcome to make the general reader, who knows but little of osteology, understand the structure of creatures that are only known from their bones, Hutchinson's book marks a decided success. Naturally this success could only be brought about by not entering into the discussion of open questions, but accepting a generally probable solution, and with this the critical part of the book is restricted within certain though often regrettable limits. The bulk of the book treats, of course, as most appealing to the general reader, of the different types of fossil vertebrata. After an introduction the first chapter is devoted to fossil footprints. The detailed history of their discovery in different countries is carefully given, but I believe this chapter will appear to the general reader as one of the dullest parts of the whole book, for while footprints are quite interesting as showing how indirectly even the soft parts of an animal can be preserved, I think the reader is rather indifferent as to whether a slab was found in 1828 or 1836. A comparison of the footprints of some animal with its skeletal remains, notably the work of L. Dollo on the footprints of *Iguanodon* when sitting, running, and walking, might easily have been substituted for some parts of the second chapter.

Turning to chapter iii, dealing with "Sea Scorpions", we find a great effort to make us understand these creatures, but their general structure is so unlike anything living that this portion might have been omitted were it not for the fact that it shows the public that in bygone times other monsters besides animals possessed of a backbone also existed on the earth.

Turning to the vertebrata, we can only congratulate the author. Ichthyosaurs and Plesiosaurs, even *Archægosaurus* and the stupid-looking *Actinodon*, seem to have come off quite well during their resurrection. The *Mastodonsaurus* on pl. ix, however, is decidedly feeling uncomfortable, for with its head turned skyward it seems as though it were about to sneeze at the next moment.

The chapter dealing with "Anomalous Reptiles" (Cotylosaurians, Thecodontia, and Anomodonts) gives reconstructions of *Pareiasaurus* and *Naosaurus*. Besides these instructive pictures several photographs of Professor Amalitzsky's Russian monsters are reproduced, and since these have never yet been adequately described Hutchinson's book contains in this respect some data that are of more than general interest even for the most critical scientific student.

Fully sixty-two pages deal with Dinosaurs, and give not only a very good account of many interesting discoveries but several

quite up-to-date illustrations. The single figure one might object to is that of the Dinosaur pelvis (fig. 40), and here one might expect to find one of von Huene's reconstructions of Triassic forms; but, of course, all such omissions, though remarkable to a specialist dealing with Dinosaurs, are of no importance in a work of this popular character. Besides numerous drawings we find quite good reconstructions of *Ceratosaurus*, *Lælaps*, *Anchisaurus*, *Brontosaurus*, *Iguanodon*, *Claosaurus*, *Hypsilophodon*, *Stegosaurus*, and *Triceratops*. We are glad to remark that *Diplodocus*, the animal that involuntarily did so much to popularize palæontology, has been likewise reconstructed in the old-fashioned way, and not in the manner advocated recently by a German writer. Williston's drawings of different Morosauria and a modification of Osborn's *Tylosaurus* reconstructed, give quite a good general idea of the 'sea-serpents' and are dealt with in chapter x. The flying dragons (Pterosauria) have, with the exception of *Scaphognathus* (*Pterodactylus*) *crassirostris*, likewise come off quite well, but the poor *Scaphognathus* has lost the greater part of its tail somewhere (p. 203 and pl. xxxii).

Hesperornis, the Moa, and the Dodo are given as types of extinct birds; the last-named, with historical truth, is figured as a stupid, sluggish creature, easily slaughtered. If anybody objects to the reconstruction of the bad-tempered and mischievous-looking *Phororhacos*, Hutchinson can easily plead 'not guilty', for its portrait is taken from a well-known book by Professor F. A. Lucas. The mammalia are represented by *Xiphodon*, *Anoplotherium*, *Palæotherium*, outline drawings of a great many old types of 'horses', by *Coryphodon*, *Tinoceras*, *Brontops*, *Arsinoetherium* (very difficult to reconstruct), many elephants as *Mœritherium*, *Palæomastodon*, *Tetrabelodon*, *Dinotherium*, and the Mammoth. The curiosity of anybody desirous to know the principal types of mammals that formerly inhabited our globe will be gratified by reading pp. 230–90 of Hutchinson's book. One would not, however, object if in the next edition another plate were substituted for that of *Megatherium*, and if the obsolete drawing of *Diprotodon* were omitted as useless, all the more since plate iv gives the same animal in a much more complete state.

Dr. Andrews' discoveries of fossil elephants have been duly considered. Since learned palæontological books as a rule do not give the history of discoveries of fossils, and even when they do, abstain from publishing the private correspondence dealing with this question, it is a very good conclusion to Hutchinson's book to publish the correspondence that concerned one of the latest bone-bed discoveries we know of, that of 'Lake Callabona'. Even scientific people will get a glimpse in this chapter of some 'subterranean' movements that might easily be forgotten. There is a long list of literature at the end of Hutchinson's book, and for a student whose interest may well have been aroused by reading this work on extinct animals, this list will be of great value to enable him to pursue the subject further.

Gilt-edged, well-printed, and lavishly illustrated with 55 plates and 113 illustrations in the text, Hutchinson's book is brought out in a manner that Continental readers would term 'luxurious', so that it is a work likely to popularize science and well worth buying and reading.

III.—Geological Survey Memoirs.

1. The Geology of the Neighbourhood of Edinburgh. Second edition. By B. N. Peach, C. T. Clough, L. W. Hinxman, J. S. Grant Wilson, C. B. Crampton, H. B. Maufe, and E. B. Bailey; with contributions by J. Horne, W. Gibson, E. M. Anderson, and G. W. Grabham; and Petrographical Chapters by J. S. Flett. 8vo, cloth; pp. xii, 445, with 12 plates, geological map, and 19 text-illustrations. 1910. Price 7*s.* 6*d.*
2. The Geology of East Lothian, including parts of the Counties of Edinburgh and Berwick. Second edition. By C. T. Clough, G. Barrow, C. B. Crampton, H. B. Maufe, E. B. Bailey, and E. M. Anderson; with contributions on the Silurian Tableland by B. N. Peach and J. Horne. 8vo, wrapper; pp. x, 226, with 12 plates and 11 text-illustrations. 1910. Price 4*s.* 6*d.*

Printed for H.M. Stationery Office, and sold by W. & A. K. Johnston, Ltd., 2 St. Andrew Square, Edinburgh, and by T. Fisher Unwin, 1 Adelphi Terrace, London.

As these two memoirs are descriptive of adjacent areas and both are second editions, we may conveniently associate our remarks upon them.

The first edition of the Geology of Edinburgh was written by H. H. Howell & A. Geikie, and published in 1861; and that on East Lothian, the work of Howell, A. Geikie, & J. Young, was published in 1866. A long interval has thus elapsed, and both memoirs required much revision and very considerable additions. More than 330 papers on the local geology are recorded in the Edinburgh bibliography as published since 1861; and in the list we find the names of numerous local workers who have contributed papers, and of these J. Henderson and D. J. Brown are more especially mentioned in the text. The new work is, however, essentially based on observations made during the re-survey or revision of the areas on the Geological Survey maps.

The Edinburgh Memoir, which has been edited by Dr. Horne, describes the geological features of the district included in the 1 inch map 32—the first published sheet of the Geological Survey in Scotland—together with a narrow belt of ground extending from Addiewell by Bathgate to Bo'ness in Sheet 31.

In the introduction is given a brief sketch of the prominent physical features and the geological history of the region. The records of the older Palæozoic rocks, comprising the Silurian formations and the lower and upper divisions of the Old Red Sandstone, are described, a special chapter being devoted to the Petrography of the Volcanic Rocks of the Pentland Hills, of which a good pictorial view is given in a plate.

The distinctive feature of the memoir is the detailed description of the various divisions of the Carboniferous System occurring within the region, including the Oil-shale fields of the Lothians, the Carboniferous Limestone Series and associated coals of Bo'ness and Bathgate, and the Mid-Lothian basin with the Edge Coals and true Coal-measures.

The Millstone Grit or Roslin Sandstone Series was rightly mapped in the original survey as one essentially arenaceous and pebbly

formation; but in accordance with the determinations of the plant and fish remains by Dr. Kidston and Dr. Traquair, the group is now considered to represent two palæontological divisions, the one Upper and the other Lower Carboniferous. It is stated that a boundary has been drawn between these subdivisions where the evidence is regarded as conclusive, but as observed (p. 244), the palæontological break is not of an absolutely definite character; two plants hitherto supposed to be confined to Lower Carboniferous in this country have since been found in Upper Carboniferous, and no stratigraphical evidence of unconformity has been detected in the series.

An interesting feature is the account of the volcanic history of the Arthur's Seat Volcano, and the special description of the petrography of the Carboniferous volcanic rocks of the Edinburgh and Linlithgow districts. Three excellent pictorial plates and a coloured geological map illustrate the geological features of Arthur's Seat. Moreover, we learn that "The re-examination of Arthur's Seat by the Geological Survey confirmed the later views of Charles Maclaren and the conclusions of Professor Judd regarding its structure, namely, that the lavas and ashes, together with the central agglomerates and their associated igneous rocks, belong to one period of volcanic activity".

The formations newer than the Coal-measures are all included under the heading of Pleistocene and Recent. They comprise Boulder-clay, Glacial sands and gravels, ancient lake-deposits with Arctic plants, raised beaches, and alluvial terraces. Evidence furnished by certain buried river channels indicates that in pre-Glacial time the land stood higher relatively to the sea than at present. In connexion with the Glacial phenomena, of special interest is a transported mass of igneous rock resting on Glacial sands and gravels at Comiston. This is illustrated in one of the plates.

The economics of the region are fully discussed. Tables are given showing the thickness, class, and quality of the various coal-seams in the Mid-Lothian basin and in the Bo'ness and Bathgate districts, and chemical analyses of various seams are quoted. A table is also given showing the physical properties of the more important building-stones of the region, and an account is presented of the water-supply of Edinburgh and the surrounding districts.

In the appendix appears a general list of Carboniferous fossils arranged in their systematic order, and this is preceded by notes on the distribution of life in the Lower Carboniferous rocks. There are also lists of Pleistocene and Neolithic organic remains.

2. The East Lothian or Haddington Memoir describes the Geology of East Lothian and the coastal belt near Cockburnspath in the adjacent county of Berwick. The introduction presents a synopsis of the rock groups and their distribution and an account of the physical features and their development. Brief descriptions are next given of the Silurian rocks of the Lammermuir Hills and of the Upper Old Red Sandstone, the latter formation in this region being associated with the classic generalizations of Hutton and of his associates, Playfair and Sir James Hall.

The greater part of the memoir is occupied by detailed descriptions of the Carboniferous rocks ranging from the Calciferous Sandstone

Series to the true Coal-measures. An interesting feature of the memoir is the history of the contemporaneous volcanic rocks of the Garleton Hills and the associated igneous intrusions, including the trachytic masses of North Berwick Law, the Bass Rock, and Traprain Law. A full account is given of the petrology of these volcanic rocks and associated intrusions; and views are given in plates of the Bass Rock and the rocks of Dunbar Castle.

The records of the Glacial period, and, in particular, the glacial drainage channels connected with the retreat of the ice-sheet, are passed in review, particulars and some illustrations being reproduced from the interesting paper by Professor P. F. Kendall and Mr. E. B. Bailey (Trans. Roy. Soc. Edin., noticed in GEOL. MAG., May, 1908, p. 231).

In the chapter on Economics particulars are given of the coals, fireclays, building-stones, agriculture, and water-supply. Lists of Carboniferous fossils are given in an appendix.

The two 1 inch geological maps described in the memoirs are Sheets 32 and 33, excellently colour-printed, and issued each at the price of 2*s.* 6*d.*, instead of 15*s.* 3*d.* and 10*s.* 3*d.*, the later prohibitive prices put on the hand-coloured maps by H.M. Treasury. An enormous amount of detail is shown largely by symbols among the igneous rocks, thirty tablets being devoted to them in the Index of Colours. The Glacial Drifts are not distinguished by colour, but only by engraved symbols.

3. THE GEOLOGY OF GLENELG, LOCHALSH, AND SOUTH-EAST PART OF SKYE. By B. N. PEACH, J. HORNE, H. B. WOODWARD, C. T. CLOUGH, A. HARKER, and C. B. WEDD; with contributions by G. BARROW, J. J. H. TEALL, J. S. FLETT, and F. L. KITCHIN. Edinburgh: printed for H.M. Stationery Office, and sold by W. A. K. Johnston, Ltd., 2 St. Andrew Square, and T. Fisher Unwin, 1 Adelphi Terrace, London. 8vo, wrapper; pp. x, 206, with 13 plates and 13 text-illustrations. 1910. Price 3*s.* 6*d.*

THIS memoir, one of the more elaborate of those issued by the Scottish branch of the Geological Survey, has been edited with great precision by Mr. Clough. It is descriptive of Sheet 71, which we are pleased to see in colour-printed form and issued at the price of 2*s.* 6*d.* Although it has no less than seventy-five tablets to represent geological formations and subdivisions, the map clearly displays the main structure of the ground, the Glacial drifts being uncoloured and indicated by signs, although by no means unimportant from an agricultural point of view.

The most ancient rocks are exposed on the eastern and southern portions of the area, in parts of the mainland of Ross and Inverness and the south-east of Skye. They are described by Messrs. Horne, Peach, and Clough. The oldest group, the Lewisian gneiss, includes thick layers of limestone, graphitic bands, and some gneisses of sedimentary origin. The Moine schists, "of uncertain age," but regarded as a newer group, give evidence pointing to the conclusion that the Moine sediments were laid down unconformably on the

Lewisian, and that the schists may be altered representatives of Torridonian strata. The effects produced by the Moine thrust, of Post-Cambrian date, and by other movements are illustrated by sections and many excellent plates.

The Torridon Sandstone, which is reckoned to be about 14,000 feet thick, occupies prominent belts in South-Eastern Skye and on the Ross-shire coast north of Kyle Akin; it occurs also in other parts of Skye and over the greater parts of Scalpa and Longay. The highest portion of the series appears in the Crowlin Islands. It is remarked that all the Torridonian rocks are probably in a thrust condition, and that the Cambrian strata have nearly all been formerly covered by Torridonian rocks, carried forward by thrusts. The various Cambrian divisions are described; *Olenellus* is recorded from the 'Fucoid Shales' of Ord Bay, and many fossils from the Durness Limestone, south of Broadford. 'Skye marble,' which was formerly worked in Strath Suardal, is now quarried to the north-west of Broadford, and it is hoped that it "may be found suitable for most of the purposes for which Italian marble is now used".

The Triassic rocks, comprising red and mottled sandstone marl and conglomerate, are well seen near Broadford and Heast, and in Raasay, and they are surmounted by passage-beds no doubt of Rhætic age, as indicated by fossils obtained by Messrs. Woodward, Wedd, and D. Tait. The Lower and Middle Lias of Broadford, Pabba, and Scalpa were well-known to previous observers, who noted the coral-beds with *Isastræa* and *Thecosmilia* and the fossiliferous shales with many Ammonites (*Jamesoni* and other zones) on Pabba and elsewhere. The headland between Loch Slapin and Loch Eishort affords good sections of the Pabba shales, as described by Mr. Barrow. In the district of Strathaird much new information has been gathered by Mr. Wedd, who has determined the sequence to range from the top of the Middle Lias to the Oxfordian and Corallian—with the absence apparently of the *Ornatus*-beds of the Oxfordian. Apart from some traces of Kellaways Beds the mass of the Oxford Clay belongs to the *Cordatus*-zone, and the strata, which consist of sandstones and shales, pass upwards into shales with Corallian fossils. This latter horizon was not separated on the map as the evidence at the time was not conclusive. The discovery by Mr. Wedd of Upper Cretaceous (Cenomanian) at Strathaird and Strollamus on Skye and on the south of Scalpa is of great interest. He considers that the Jurassic rocks were subjected to considerable earth-movements prior to the deposition of the Upper Cretaceous.

The Tertiary igneous rocks of the eastern Cuillins with Blathbheinn (Blaven) and the Red Hills have been described in a special memoir by Mr. Harker (1904), and a summary only of the leading facts and conclusions is now given. To Mr. Harker also we are indebted for a luminous essay on Ice-Erosion in the Cuillin Hills (noticed in the Geological Magazine for January, 1902, p. 35), so that this most interesting subject is dealt with less fully in the memoir than it otherwise might have been. The final chapters treat of raised beaches, recent deposits, and economics; and there are palæontological and bibliographical appendices.

4. The Geology of the Country around Padstow and Camelford. By Clement Reid, G. Barrow, and Henry Dewey; with contributions by J. S. Flett and D. A. MacAlister. London: printed for H.M. Stationery Office, and sold by E. Stanford, Long Acre, and T. Fisher Unwin, 1 Adelphi Terrace. 8vo; pp. vi, 120, with 4 plates and 7 text-illustrations. 1910. Price 2*s.* 3*d.*

THIS memoir has been written in explanation of Sheets 335 and 336 of the New Series Geological Survey map of England. The area thus takes in portions of the north Cornish coast, from the famous Bedruthan Steps to Trevose Head and Harlyn Bay, Padstow, Pentire Point, and Port Isaac; it includes also the little towns of Wadebridge and Camelford, and a large part of Bodmin Moor. The maps show, for the first time, the divisions of Lower, Middle, and Upper Devonian, but it must be confessed that the colouring of the Upper Devonian slate is so nearly like that of the Middle Devonian that the distinction is not apparent without a close inspection. The physical features of Bodmin Moor are made manifest by the mapping of the Alluvium and Peat, which are separately coloured in the Index tablets but not on the map. An important addition is the indication of the petrological characters of the metamorphic aureole surrounding the Bodmin granite. There the altered Devonian rocks include sundry schists, and also calc-flintas "where the calcareous rocks have been converted into insoluble lime-silicates".

The Lower Devonian rocks have yielded but few fossils, including *Homalonotus*; in the Middle Devonian slates, thanks to the painstaking labours of Mr. Howard Fox, many fossils have been found, and notably species of *Pteraspis* and *Scaphaspis*; while to Mr. Fox again, who discovered the Büdesheim fauna in Trevone Bay, our knowledge of the Upper Devonian fossils is chiefly due. The specimen of *Homalonotus Barratti*, which was found by Mr. Walter Barratt and described by Dr. Henry Woodward, is referred to the Upper Devonian of Mother Ivey's Bay (not Portheothan). Important additions to the lists of fossils have been made during the progress of the Geological Survey, especially from the Upper Devonian of Port Quin, where many specimens were collected and developed by Mrs. Clement Reid.

The contemporaneous volcanic rocks, spilites, schalsteins, and tuffs have been separated from the 'greenstones' or diabases. The pillow-lavas, grouped as spilites, were described by Messrs. Reid and Dewey in a paper published by the Geological Society, and although particulars are given in the memoir, it is to be regretted that the illustrations of these remarkable and interesting features have not been reproduced. In connexion with the subject Dr. Tempest Anderson's account of the formation of pillow-lava in Savii, one of the Samoa Islands (Q.J.G.S., lxvi, p. 632, 1910), may be read with advantage.

Particulars are given of the granites, elvans, and minettes, and of the thermometamorphism surrounding the granite. An excellent view of Roughtor illustrates the characters of tors that "are built up of lenticular blocks or sheets of granite".

Attention is drawn to the features of Pliocene and earlier age, to the Raised Beaches and River Terraces, and to the connexion between the amount of superficial deposits and the history of the valleys.

Special interest attaches to the Stream Tin and Wolfram Deposits, and we wonder why the illustrations of these deposits, of so much practical as well as general interest, are not reproduced from the paper communicated to the Geological Society in 1908 by Mr. Barrow. To the greater number of residents it is probable that the subject would be more attractive than the petrographical descriptions (important as they are) which occupy nearly half the memoir.

In the chapter on Economics there are accounts of the famous slates of De la Bole, of the Cataclews rock (proterobase), the De Lank granite, and the China clay, the metal-mining, and water-supply.

Reference is made to the ancient British cemetery at Harlyn Bay, and mention might appropriately have been made, in a footnote, of the pamphlet by the Rev. R. Ashington Bullen on "Harlyn Bay and the discoveries of its Prehistoric Remains", 2nd ed., 1902.

IV.—English Provincial and Scottish Geological Societies.

Liverpool Geological Society.—The Proceedings of this Society (vol. xi, pt. i, 1910) contain a brief account of the celebration of the Society's Jubilee, and the Address which Professor J. W. Judd delivered on that occasion on "The Triumph of Evolution: a retrospect of Fifty Years". This subject has been more fully dealt with by him in a recently published work entitled *The Coming of Evolution*. Mr. T. H. Cope writes "On the Recognition of an Agglomerate"; and Mr. C. B. Travis gives particulars of some borings carried through Glacial Drift into Keuper and Bunter Sandstones near Burscough, north of Ormskirk. He draws attention to the evidence of a buried pre-Glacial valley. In one boring the Drift was 240 feet thick.

Liverpool Geological Association.—In the part of the Proceedings (New Series, No. 4, 1910) which contains records of the sessions 1907–9, Mr. C. B. Travis gives some useful hints on "Field Work among Igneous Rocks"; Mr. J. G. Learoyd deals with "Pressure in relation to Thickness of Ice"; Mr. T. A. Jones discusses the "Augite Porphyrite" of Scarlett Stack, Isle of Man, a rock which he regards as a decomposed basalt and the remnant of a lava-sheet; and Mr. H. W. Greenwood considers "Some Problems in Rock Genesis and Metasomatism".

Yorkshire Geological Society.—In the well-illustrated Proceedings of this Society (N.S., vol. xvii, pt. ii, 1911) Dr. Wheelton Hind describes four new species of Nautiloids, including one new genus, *Cyclonautilus*, also one Goniatite, *Glyphioceras vesculifer*, de Kon., from the Carboniferous rocks of Yorkshire and Lancashire; Mr. Frank W. White gives a detailed account of the complex of igneous rocks at Oatland, Santon, Isle of Man, with micro-sections of the rocks; Mr. E. A. Newell Arber contributes an article on the Fossil Flora of the Coalfield in North Derbyshire and Nottinghamshire, illustrated by eight excellent plates of fossil plants; and Mr. G. W. Lamplugh has written obituary memoirs (with portraits) of C. Fox-Strangways and J. R. Dakyns.

Hull Geological Society.—The Transactions of this Society, vol. vi, pt. ii, contain the record of work done during the years 1906–9; and include papers on the Fossil Cephalopoda of the

Holderness Drift, and on the Belemnites of the Yorkshire Lias, by Mr. C. Thompson; on the Pleistocene fossiliferous beds of Bielsbeck, near Market Weighton, by Mr. J. W. Stather; together with miscellaneous notes and a useful geological bibliography for E. Yorkshire and N. Lincolnshire, 1906–9, by Mr. T. Sheppard.

Edinburgh Geological Society.—The Transactions of this Society (vol. ix, pt. v, 1910) contain, among other articles, papers by Dr. S. J. Shand on some Scottish granite-gneiss contacts in the counties of Aberdeen and Argyll, and on Borolanite and its associates in Assynt, with chemical analyses by Mr. A. Gemmell. Dr. Shand calls attention to evidence that favours the theory of assimilation of lime from underlying Cambrian Limestone in portions of the igneous complex of Cnoc-na-Sroine in Assynt. Numerous illustrations accompany these papers.

Glasgow Geological Society.—The Transactions of this Society (vol. xiv, pt. i, 1910) open with the Address of the President, Professor J. W. Gregory, who selected for his subject "Work for Glasgow Geologists: the Problems of the South-Western Highlands". He gives an interesting and instructive account of the work of the many geologists who have laboured among the schistose rocks of Argyllshire and Perthshire, and of the numerous difficulties and problems involved in their study. As an aid to further research he has drawn up a table showing the geographical succession and geological correlation of the various Dalradian rocks, remarking in advance that "two of the chief present riddles of Scottish geology are, what is the age of this Dalradian System, and which is the top and which is the bottom of its long succession of deposits?"

The Carboniferous rocks of the Solway borders are described by Mr. John Smith, who deals very fully with the fossils, and describes some new species of sponges, turbellaria, annelids, etc. His paper is illustrated by eight plates. Mr. R. G. Carruthers deals with zonal work in Lower Carboniferous rocks and on the collecting of fossils; and Mr. R. Dunlop gives an account of the fossil Amphibia in the Kilmarnock Museum previous to the fire of 1909. It is satisfactory to learn that a good many fossils have been recovered from the debris of that disastrous fire.

V.—Brief Notices.

1. Some Features of Alpine Scenery.—In an interesting and well-illustrated essay Professor E. J. Garwood has drawn attention to "Features of Alpine Scenery due to Glacial Protection" (*Geograph. Journ.*, September, 1910). As he remarks at the outset, "No one with any knowledge of glaciated regions doubts that moving ice erodes," but his object is to bring forward evidence to show that ice, on the whole, erodes less rapidly in the Alps than other denuding agents, and under certain conditions may act as a protective agent.

2. Ice on Canadian Lakes.—This subject is dealt with by Mr. J. B. Tyrrell (Trans. Canadian Inst., ix, 1910), whose observations establish the following points. In regions of heavy snowfall the ice is being constantly pressed down into the water by the weight of snow, and therefore there is often water over it and beneath the snow. In these

regions the ice increases in thickness mostly from the top, by the freezing of the overflowing water; but in other regions of light snowfall it increases mostly from the bottom. Throughout the winter the ice remains firmly frozen to the shore, except that it falls with the lowering of water in the lakes. In the spring it thaws along the shore, and around any stones. Loose ice floating on the water is then pushed against the shore by wind, and sand and stones are thrust up by and in front of it, often to the back of the beach, and there piled into rough and heavy walls or ramparts.

3. Beekite.—An article on this form of orbicular chalcedony is contributed by Mr. W. H. Wickes (Proc. Bristol Nat. Soc., 1910). Named after Henry Beeke, Dean of Bristol (born in 1751 and died in 1837), who first called attention to the mineral, the original describer appears to be unknown. After dealing as far as possible with references to the same mineral substance, dating back to 1751, Mr. Wickes gives a list of formations and fossils showing how widely distributed are the incrustations of Beekite, from an *Orthoceras* in the Cambrian Limestone of Durness to the Norwich Crag. It occurs only on marine calcareous organisms, and in the opinion of the author the material has been deposited from silica in solution in sea-water, in and around cavities produced in the shells and other organic structures by boring animals.

4. Catalogue of Photographs of Geological Subjects, prepared by the Geological Survey and Museum. 8vo; pp. 62. Price 6*d*. Edinburgh, 1910.—This work, issued as a memoir of the Geological Survey of Scotland, supplements that relating to England and Wales, which was noticed in the Geological Magazine for July, 1910, p. 330. The Scottish Survey has been longer engaged in the taking of photographs of geological interest, and the number now catalogued amounts to 676 whole-plate and 1,237 half-plate subjects, as against a total of 800 in the English collection. Among the Scottish subjects, of which brief descriptions are given in the Catalogue, are many features in the Lewisian gneiss, Torridonian, and Cambrian (including great thrusts), Ordovician, Carboniferous, Triassic, and Jurassic. The igneous rocks of Skye, Arran, Argyll, and Ayr are well illustrated; likewise glacial phenomena, landslips, screes, faults, arches, caves and various forms of weathering, peat-mosses, etc. Negatives, prints, lantern-slides, and bromide enlargements of any of these photographs can be obtained at a fixed tariff, on application to the Director, Geological Survey, either at 33 George Square, Edinburgh, or at 28 Jermyn Street, London.

REPORTS AND PROCEEDINGS.

I.—Geological Society of London.

1. *January* 25, 1911.—Professor W. W. Watts, Sc.D., M.Sc., F.R.S., President, in the Chair.

The following communication was read:—

"The Skomer Volcanic Series (Pembrokeshire)." By Herbert Henry Thomas, M.A., B.Sc., F.G.S.

This series of volcanic rocks is developed in the west of Pembrokeshire, and takes its name from the island of Skomer, where the

Holderness Drift, and on the Belemnites of the Yorkshire Lias, by Mr. C. Thompson; on the Pleistocene fossiliferous beds of Bielsbeck, near Market Weighton, by Mr. J. W. Stather; together with miscellaneous notes and a useful geological bibliography for E. Yorkshire and N. Lincolnshire, 1906–9, by Mr. T. Sheppard.

Edinburgh Geological Society.—The Transactions of this Society (vol. ix, pt. v, 1910) contain, among other articles, papers by Dr. S. J. Shand on some Scottish granite-gneiss contacts in the counties of Aberdeen and Argyll, and on Borolanite and its associates in Assynt, with chemical analyses by Mr. A. Gemmell. Dr. Shand calls attention to evidence that favours the theory of assimilation of lime from underlying Cambrian Limestone in portions of the igneous complex of Cnoc-na-Sroine in Assynt. Numerous illustrations accompany these papers.

Glasgow Geological Society.—The Transactions of this Society (vol. xiv, pt. i, 1910) open with the Address of the President, Professor J. W. Gregory, who selected for his subject "Work for Glasgow Geologists: the Problems of the South-Western Highlands". He gives an interesting and instructive account of the work of the many geologists who have laboured among the schistose rocks of Argyllshire and Perthshire, and of the numerous difficulties and problems involved in their study. As an aid to further research he has drawn up a table showing the geographical succession and geological correlation of the various Dalradian rocks, remarking in advance that "two of the chief present riddles of Scottish geology are, what is the age of this Dalradian System, and which is the top and which is the bottom of its long succession of deposits?"

The Carboniferous rocks of the Solway borders are described by Mr. John Smith, who deals very fully with the fossils, and describes some new species of sponges, turbellaria, annelids, etc. His paper is illustrated by eight plates. Mr. R. G. Carruthers deals with zonal work in Lower Carboniferous rocks and on the collecting of fossils; and Mr. R. Dunlop gives an account of the fossil Amphibia in the Kilmarnock Museum previous to the fire of 1909. It is satisfactory to learn that a good many fossils have been recovered from the debris of that disastrous fire.

V.—Brief Notices.

1. Some Features of Alpine Scenery.—In an interesting and well-illustrated essay Professor E. J. Garwood has drawn attention to "Features of Alpine Scenery due to Glacial Protection" (*Geograph. Journ.*, September, 1910). As he remarks at the outset, "No one with any knowledge of glaciated regions doubts that moving ice erodes," but his object is to bring forward evidence to show that ice, on the whole, erodes less rapidly in the Alps than other denuding agents, and under certain conditions may act as a protective agent.

2. Ice on Canadian Lakes.—This subject is dealt with by Mr. J. B. Tyrrell (Trans. Canadian Inst., ix, 1910), whose observations establish the following points. In regions of heavy snowfall the ice is being constantly pressed down into the water by the weight of snow, and therefore there is often water over it and beneath the snow. In these

regions the ice increases in thickness mostly from the top, by the freezing of the overflowing water; but in other regions of light snowfall it increases mostly from the bottom. Throughout the winter the ice remains firmly frozen to the shore, except that it falls with the lowering of water in the lakes. In the spring it thaws along the shore, and around any stones. Loose ice floating on the water is then pushed against the shore by wind, and sand and stones are thrust up by and in front of it, often to the back of the beach, and there piled into rough and heavy walls or ramparts.

3. Beekite.—An article on this form of orbicular chalcedony is contributed by Mr. W. H. Wickes (Proc. Bristol Nat. Soc., 1910). Named after Henry Beeke, Dean of Bristol (born in 1751 and died in 1837), who first called attention to the mineral, the original describer appears to be unknown. After dealing as far as possible with references to the same mineral substance, dating back to 1751, Mr. Wickes gives a list of formations and fossils showing how widely distributed are the incrustations of Beekite, from an *Orthoceras* in the Cambrian Limestone of Durness to the Norwich Crag. It occurs only on marine calcareous organisms, and in the opinion of the author the material has been deposited from silica in solution in sea-water, in and around cavities produced in the shells and other organic structures by boring animals.

4. Catalogue of Photographs of Geological Subjects, prepared by the Geological Survey and Museum. 8vo; pp. 62. Price 6*d*. Edinburgh, 1910.—This work, issued as a memoir of the Geological Survey of Scotland, supplements that relating to England and Wales, which was noticed in the Geological Magazine for July, 1910, p. 330. The Scottish Survey has been longer engaged in the taking of photographs of geological interest, and the number now catalogued amounts to 676 whole-plate and 1,237 half-plate subjects, as against a total of 800 in the English collection. Among the Scottish subjects, of which brief descriptions are given in the Catalogue, are many features in the Lewisian gneiss, Torridonian, and Cambrian (including great thrusts), Ordovician, Carboniferous, Triassic, and Jurassic. The igneous rocks of Skye, Arran, Argyll, and Ayr are well illustrated; likewise glacial phenomena, landslips, screes, faults, arches, caves and various forms of weathering, peat-mosses, etc. Negatives, prints, lantern-slides, and bromide enlargements of any of these photographs can be obtained at a fixed tariff, on application to the Director, Geological Survey, either at 33 George Square, Edinburgh, or at 28 Jermyn Street, London.

REPORTS AND PROCEEDINGS.

I.—Geological Society of London.

1. *January* 25, 1911.—Professor W. W. Watts, Sc.D., M.Sc., F.R.S., President, in the Chair.

The following communication was read:—

"The Skomer Volcanic Series (Pembrokeshire)." By Herbert Henry Thomas, M.A., B.Sc., F.G.S.

This series of volcanic rocks is developed in the west of Pembrokeshire, and takes its name from the island of Skomer, where the

maximum thickness is exposed. The rocks are traceable on the mainland from near St. Ishmaels on Milford Haven to Wooltack Head, and on the west occupy the islands of Midland, Skomer, and the Smalls. The thickness exposed is some 3,000 feet, and the lateral extension some 25 miles. The district described is that portion of the mainland known as the Wooltack Peninsula, and the islands on the west. The chief evidence bearing on the age of the series is obtainable from the mainland sections, and indicates that the rocks are of pre-Upper Llandovery age; but, from a consideration of the geology of the neighbouring country, it is probable that their true age is Arenig. The rocks are chiefly subaërial lava-flows of extreme thinness and great lateral extent; they are frequently interstratified with red clays, and are separated into two main groups by a thick mass of sedimentary rocks barren of fossils. There is an almost complete absence of pyroclastic rocks, a fact which points to the eruptions being of the fissure type.

The lavas form well-defined groups in the field, and range from extremely acid varieties with a silica percentage of about 80 to others with a percentage of less than 50. The rocks of the series fall into eight chief types, two of which are of necessity new; in order of increasing basicity they are as follows: soda-rhyolites, soda-trachytes (including olivine- and hypersthene-bearing varieties), keratophyres, skomerites, marloesites, mugearites, olivine-basalts, and olivine-dolerites. The last-named are probably intrusive. All these types are described in the paper, and several analyses are tabulated. The first five types may be included in the alkaline class; they are rich in soda, and most of the felspars belong to albite-oligoclase varieties. The last three types are normal sub-alkaline rocks, in which the felspars range from oligoclase to labradorite.

The author does not consider that the Skomer rocks have been albitized to a sufficient degree to mask their original characters, and regards them as a mixture of alkaline rocks of Pantellerian affinities, with a subordinate series of more basic sub-alkaline rocks, the most basic of which are probably intrusive.

At 7 p.m., before the Ordinary Meeting, a Special General Meeting, at which 92 Fellows were present, was held in order to consider the resolutions submitted to them by the Council (see GEOL. MAG., February, p. 94).

Resolutions *a*, *b*, and *d* were carried unanimously, and Resolution *c* was carried by 57 Ayes to 10 Noes.

2. *February* 8, 1911.—Professor W. W. Watts, Sc.D., M.Sc., F.R.S., President, in the Chair.

Professor T. W. Edgeworth David, C.M.G., D.Sc., F.R.S., F.G.S., gave an account of the researches pursued by him in conjunction with Mr. R. E. Priestley, Geologist to the British Antarctic Expedition of 1907–9, in the course of that expedition, more especially the investigations connected with glacial geology. The lecture, which was illustrated by a series of beautiful lantern-slides and by numerous rock-specimens collected from the Antarctic continent, was

followed by a discussion, in which Sir Ernest Shackleton, Professor P. F. Kendall, Mr. G. W. Lamplugh, Mr. Clement Reid, Dr. Tempest Anderson, and Professor E. J. Garwood took part.

II.—Mineralogical Society.

January 24, 1911.—Prof. W. J. Lewis, F.R.S., President, in the Chair.

F. H. Butler: On Kaolin. The kaolinite in the Glamorganshire Coal-measures originated in the decomposition of felspar by carbonated underground water. The secondary mica and quartz of the Carboniferous grits and greisens are due primarily to the formation of potassium carbonate and alumohexasilicic acid (Morozewicz), the acid breaking up into silica and alumdisilicic acid (i.e. kaolin less water of crystallization) and the latter combining with the carbonate to yield muscovite and free carbonic acid. Kaolinite is destroyed concurrently with the growth of schorl in kaolin-rock, and cannot therefore be a product of boration.—Dr. G. T. Prior and Dr. G. F. H. Smith: On Schwartzembergite. Analyses recently made by the former show that this mineral is a complex iodate and oxychloride of lead, $Pb(IO_3)_2 3[Pb Cl_2 . 2 Pb O]$.—A. Hutchinson: An improved form of Total Reflectometer. The instrument is a goniometer of the suspended type, with a large base plate, to which a telescope and collimator, a microscope bisecting the angle between them, and other apparatus can be clamped, and is intended for the measurement of minute crystals, and the determination of the optic axial angle of biaxial crystals and of the refractive indices by Kohlrausch's method.—T. Crook: A case of Electrostatic Separation. The apparatus consists of two copper plates, one of which is coated on one side with a layer of shellac. Good conducting minerals are attracted to the shellac-covered surface of the upper plate when it is charged by means of an electrophorus.

III.—Zoological Society of London.

February 7, 1911.—Professor E. A. Minchin, M.A., Vice-President, in the Chair.

Dr. C. W. Andrews, F.R.S., F.Z.S., exhibited a skull of a Sabre-toothed Tiger (*Smilodon Californicus*) from an asphalt deposit in California, and pointed to anatomical characters which tended to prove that the animal used its large canines for stabbing and tearing, not for biting.

Professor J. Cossar Ewart, M.A., F.R.S., F.Z.S., gave an account of his memoir entitled "Skulls of Oxen from the Roman Station at Newstead, Melrose", illustrating his remarks by lantern slides. He stated that examination of the skulls from Newstead lent support neither to the descent of all European cattle from the Urus (*Bos primigenius*) nor to the descent of all European, Indian, and African breeds from the Asiatic Urus (*B. nomadicus*). He dealt with the evidence to be derived from the maxillæ, the occiput, and the temporal fossæ, and stated his conclusions as follows:—

1. That the Celtic Shorthorn (*B. longifrons*) is probably more intimately related to the Zebu of India (*B. indicus*) than to the European Urus (*B. primigenius*).

2. That long premaxillæ are usually correlated with an occiput of the *B. primigenius* type, while short premaxillæ are usually correlated with an occiput of the *B. acutifrons* type.

3. That polled black Galloway cattle and polled white 'wild' Cadzow cattle are intimately related to the Urus, that flat-polled Aberdeen-Angus cattle probably include amongst their ancestors an ancient Oriental race now represented by, amongst others, a Syrian breed with rudimentary horns, and that round-polled cattle may belong to a still more ancient Oriental race descended from *B. acutifrons* of the Punjab Siwaliks.

CORRESPONDENCE.

LATERITE IN BRITISH GUIANA.

Sir,—I notice with regret that there are several typist's errors in the last part of my laterite paper. Some uncorrected pages of typescript appear to have been sent to you in place of the corrected ones which I have here. The errors are all in the December Number, 1910.

Page 559, line 20, *read* it *for* them.
p. 559, l. 27, *read* tropics *for* Indies.
p. 560, l. 18, *insert* the nature *before* of which.
p. 560, l. 38, *read* alluvial *for* alkaline.
p. 560, l. 41, *read* and is resistant *for* which is resistant.
p. 561, footnote, l. 2, *read* rocks *for* rock.
p. 561, footnote, l. 5, *insert* boiled *between* recently *and* distilled.
p. 561, footnote, l. 13, *delete* then.
p. 561, footnote, l. 14, *read* and *for* or in.
p. 561, footnote, l. 16, *read* experiment *for* experiments.
p. 561, footnote, l. 18, *read* showed the action *for* show it.
p. 562, l. 2, *read* silica *for* silicate.
p. 562, l. 3, *read* into *for* with.

I regret that these slips should have occurred in my MS.

J. B. Harrison.

Science and Agriculture Department,
Georgetown, Demerara, British Guiana.
January 6, 1911.

HIGH-LEVEL SHELLY GRAVEL.

Sir,—With reference to my letter in the Geological Magazine for January, and a reply by Mr. Lamplugh in the February number, I hasten to assure Mr. Lamplugh that I have never regarded him as a "docile" glacialist. On the other hand, I have long been duly impressed with his restiveness; and if the phrase "docile glacialist" is to some extent a contradiction in terms, Mr. Lamplugh is quite justified in claiming that he has done his best to make it so.

I must, however, reassert my statement that the 'land-ice' glacialists, including himself, have advocated a conception of glacier-progression which is quite inadequate to explain the transportation of gravel to high levels. If I may again state this crude conception briefly, it is that the front of the ice-sheet is pushed bodily uphill, carrying morainic material with it. The fact that this has been seen

to take place on a small scale at the tip of a thin ice-lobe is, as Professor Bonney has remarked, not sufficient to justify the view that this is the manner in which gravels have been transported by ice to high levels.

Professor Bonney quotes Professor Kendall as saying that there is "no logical halting-place between an uplift of ten or twenty feet to surmount a *roche moutonnée*, and an equally gradual elevation to the height of Moel Tryfaen". Mr. Lamplugh is surely referring to the same bodily upbending of the front of an ice-sheet when he writes of "the characteristic upturning of the layers of ice at the end of one of the glacial lobes", as observed by Professor R. D. Salisbury in Greenland (York Address, Brit. Assoc. Rep., 1906, p. 543).

Nowhere in his writings, as far as I know, does Mr. Lamplugh recognize the importance of overthrust in ice-movement, as this has been described by Professor T. C. Chamberlin, and amplified later by Professors Garwood and Gregory (Q.J.G.S., vol. liv, 1898). I think Mr. Lamplugh cannot have read my letter with sufficient care, or he would not have considered it to be a mere repetition of views previously advanced and duly appreciated by him.

It seems to me that the land-ice hypothesis would get along much better if we heard rather less of "the characteristic upturning of the layers of ice at the end of the lobes", and rather more of the upthrust action in the main body of the ice, as demonstrated by Professors Chamberlin, Garwood, and Gregory; and I am pleased that I have been able to elicit from Mr. Lamplugh a plain repudiation of what is obviously a crude conception.

T. Crook.

MISCELLANEOUS.

Iron-ore in Raasay.[1]

The recent announcement of the discovery of a valuable deposit of iron-ore in the Island of Raasay has been received with the greatest interest in iron and steel trade circles in the West of Scotland. The deposit was originally discovered in 1893 by Mr. H. B. Woodward, F.R.S., F.G.S., of the Geological Survey, who contributed an instructive article on the subject to the Geological Magazine[2]; but the credit of investigating it in the interests of commerce belongs to Mr. Wallace Thorneycroft, who has been engaged in preliminary exploring work in the island during the greater part of last year. It is reported that Messrs. William Baird & Co., Limited, iron-masters, of Gartsherrie, have purchased the island from Mrs. Wood, the present proprietrix, with the view of further proving and developing the property. The deposit is situated at the junction of the Upper and Middle Lias, which corresponds approximately with the geological position of the Cleveland ironstone. On the eastern

[1] From the *Glasgow Herald*, December 31, 1910.

[2] "On a Bed of Oolitic Iron-ore in the Lias of Raasay": Geol. Mag., November, 1893, p. 493. See also British Association Reports, Section C (Geology), Nottingham Meeting.